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P. 126, line 16, for *Canadense* read *Canadensis.*

P. 137, footnote 6, for Hedgwigia read Hedwigia.

P. 142, line 19 from top, for southeastern read southwestern.

P. 160, line 2 from below for granuel read granule.

P. 218, line 4, for morophological read morphological.

P. 265, line 16 for **Castilleia pallida** read CASTILLEIA PALLIDA.

P. 299, line 3, for **11** read **24**.

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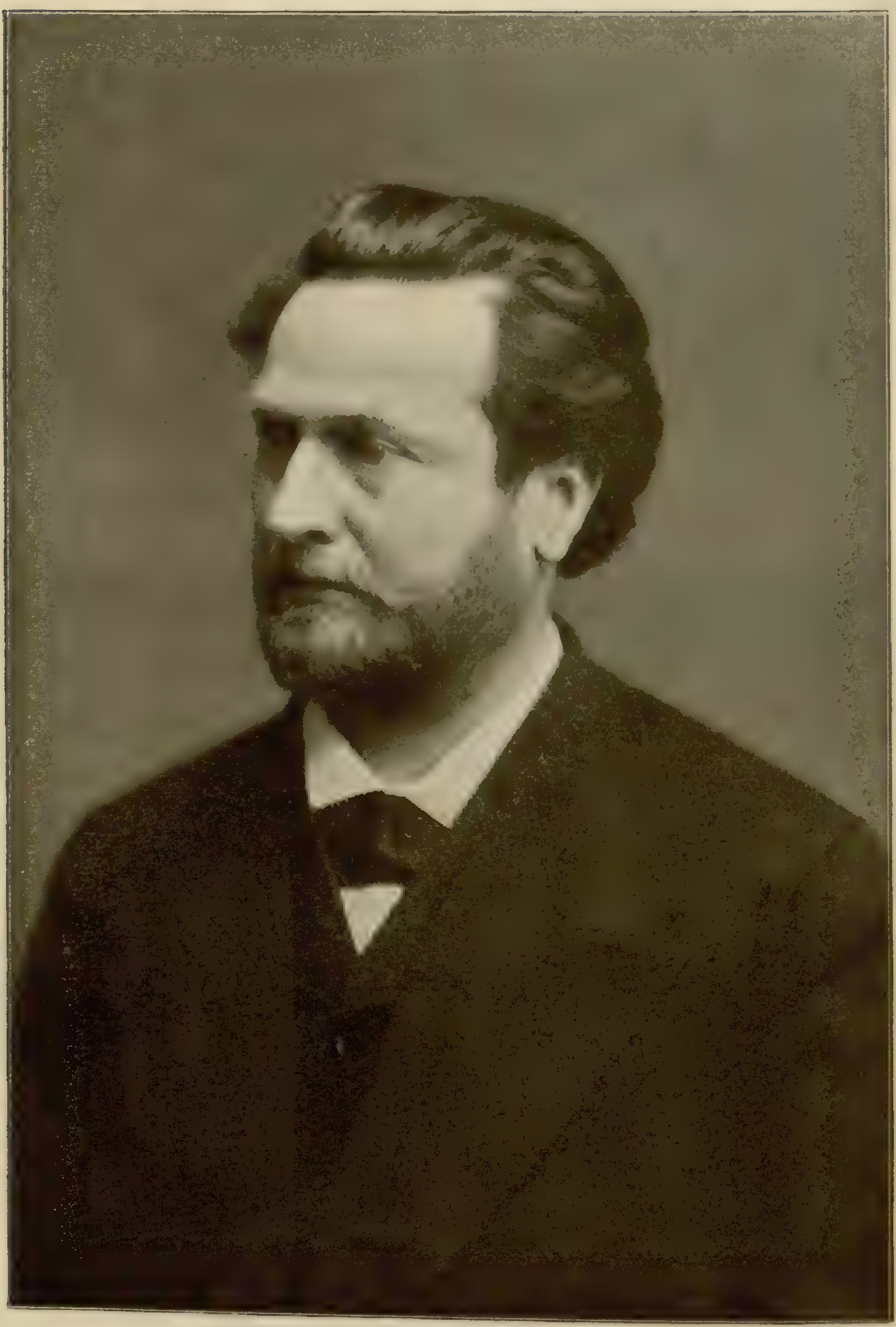

Dr. J. v. Sachs.

VOLUME XXV NUMBER 1

BOTANICAL GAZETTE

JANUARY 1898

JULIUS VON SACHS.

A BIOGRAPHICAL SKETCH: WITH PORTRAIT.

F. NOLL.

[In the preparation of this sketch for the BOTANICAL GAZETTE, Dr. Noll concluded that the very full one which he had prepared for *Naturwissenchaftliche Rundschau*, and which appeared in the issues of September 4 and 11 (1897) of that journal, had better be translated and abridged. This has been done by John G. Coulter.—EDS.]

ON May 29, 1897, death released from a long struggle with a hopeless illness a man who, in the fullness of his power, had left a permanent impress upon research in vegetable physiology. In the history of physiology his name will be inseparably connected with an epoch of great advance, of exact investigation, and of extension of physiological study into all structure.

Julius Sachs, the third son of Graveur Sachs, was born at Breslau, October 2, 1832.[1] The quiet family life was largely spent in the country, and the awakening mind of Sachs was early directed toward the observation of nature. With passionate zeal he collected all obtainable plant forms, pressed, identified, and even cultivated them, without, however, losing all the lively interest of a boy in other amusements.

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[1] In my statements regarding the family, I am dependent upon the material which the younger daughter of Dr. Sachs, Fraulein Marie Sachs, has kindly placed at my disposal. I am especially indebted also to Professor F. Cohn, Professor Goebel, Professor Körnicke, Professor Nobbe, Professor Strasburger, and Ministerial-Director Dr. H. Thiel, for their invaluable assistance.

Near the town house of the Sachs at Breslau there stood in a large garden a small one-storied structure, insignificant from without, and much restricted within. From this unpretentious building, however, there was exerted upon the scientific world without a mighty influence, and from this place there went out young men inspired by the zeal of an exact, experimental investigator, and pledged to enrich the store of biological knowledge. That little house was the laboratory of the famous physiologist Purkinje. It was, perhaps, the first place where exact physiological experiments were successfully performed. In this garden young Sachs was the playmate of the two sons of Purkinje. They were three keen and enthusiastic observers with a common and absorbing interest in nature. Purkinje, who, in addition to his studies in animal physiology, occupied himself to some extent with botanical investigations, very soon recognized the gifts of young Sachs, and aroused in him an active interest in the work of the laboratory. At this time, besides Sachs, there were others at work in the Purkinje laboratory who later became noteworthy botanists. Among these were Ferd. Cohn and N. Pringsheim.

At about this time heavy misfortune fell to the lot of the Sachs family. In 1848 an apoplectic stroke killed the father, and scarcely a year later cholera took from the seventeen-year-old boy his mother and a brother. Not yet out of the gymnasium, young Sachs was thrown wholly upon his own resources. With new determination he continued his work at sketches, lithographs, and painting, and sought thereby to sustain himself at his studies. That was no easy task, however, and already the young man, with his characteristic determination, had decided to become a sailor, when Purkinje, who had meanwhile accepted a call to Prague, afforded him an opportunity to come there. Sachs was received as a son into the Purkinje house at Prague. He was enabled to complete his interrupted course at the Gymnasium, and meanwhile assisted Purkinje, and had much to do with the making of illustrative wall charts, and with microscopical work. Purkinje, a keen investigator, with a talent for geniality and cordiality, responsive in his contact with young people, must have been in his domestic life a strong master, who was a little particular and exacting in his methods of training. Sachs, who in his young years was certainly accustomed to work and privation, has repeatedly made mention of the "harte Arbeit" with which he had to make recompense for the privilege of his sojourn at the Purkinje establishment. In order to satisfy all the demands which were made upon him, it became necessary for him to reinforce his often exhausted nerves with artificial stimulants, whose use, learned here, finally became fatal to the never resting man.

Having successfully passed the entrance examinations, Sachs was admitted as a student at the University of Prague in 1851. For a short time he attended the lectures of the botanist, Kosteletzky, and later those of Willkomm. He occupied himself somewhat with physics and mathematics, but was especially interested in philosophy under the direction of Professor Zimmermann, who won a great influence over the student, and deemed him worthy of a friendship almost paternal. The work which he carried on at the same time in the Purkinje laboratory was limited exclusively to animal physiology.

In Prague, through the influence of Purkinje, Sachs learned Bohemian, and was induced to publish a number of scientific contributions in the Bohemian journal *Ziva*, which he signed with a Bohemian name.[2]

In 1855 his name appeared in the *Botanische Zeitung* for the first time in any German scientific journal. The very first contribution of the young investigator, dated 1853, gives evidence of his keen insight. It is his account of *Collema bulbosum* (*pulposa*), in which he discussed the change which he had observed in nostoc colonies growing in Collema, and urged that this "Unwandlung" was caused by the appearance of "gleichsam parasitischer Pilzfäden" in union with the nostoc. Sachs himself doubtless did not recognize at this time the "Sachverständigen," whose first prophecy he here expressed, and which, later, an exhaustive study was to bring finally to general acceptance. This first presentation, however, is of much historical interest, inasmuch as it describes for the first time the organic interdependence of lichen fungi and algæ. Probably it was the fault of circumstances that this presentation of Sachs was omitted from the "Register," and that this important contribution has been so generally overlooked. Even in the work of Reess, in which sixteen years later the synthesis between the nostoc of Collema and the Collema-hyphæ is noted, no mention is made of the precisely similar observations of Sachs.

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[2] A German list of the titles of these publications occurs in the catalogue which is published with Goebel's "Nachruf," Flora, supplementary volume of 1897, p. 126.

In 1856 Sachs received his degree, and a year later separated himself from Purkinje and began to devote himself to the study of plant physiology. To obtain means for living, however, he continued to devote some attention to drawing and to writing. Problems pertaining to seed germination, and the earliest development of plant organs, attracted his attention before all else, and chief among the work undertaken in this first period at Prague was the inauguration of studies upon germination, which even now are having their continuation in the latest observations upon metabolism and "Stoff-wanderung."

In April of 1859, through the solicitation of the zoologist Stein, and upon the recommendation of Hofmeister, Sachs was called to Tharand as an assistant to Professor A. Stöckhardt. When Stöckhardt learned from the friends of Sachs of the water-culture experiments which the latter had begun at Prague, he recommended that the scope of the experiment station at Tharand be extended so that experimental plant physiology might be introduced upon no mean scale, and that the "especially well qualified Dr. Julius Sachs, of Prague" be called to take charge of the new department. And so at Tharand, jointly with Stöckhardt, Sachs carried out that pioneer work of his upon the nourishment of plants studied by means of water-cultures. A whole series of contributions, appearing for the most part in the *Landw. Versuchs-Stat.*, bear eloquent testimony to his ceaseless activity during the comparatively short sojourn at Tharand.

Early in 1861 Sachs was elected head of the newly created experiment station for plant physiology and docent in plant and animal physiology at Chemnitz, but before he entered definitely upon his duties there, he accepted a call, received in April of the same year, to a professorship in the agricultural academy at Poppelsdorf. Here, at first, he had charge of both plant and animal physiology and mineralogy.

At Poppelsdorf Sachs married an Austrian lady, a talented woman, whose limited income enabled the maintenance of a very modest establishment. At this time Sachs' salary was but 700 thalers.

The laboratories of the investigator were at this time as modest and limited as his domestic establishment. Two very small rooms, and an apartment in the basement, which also served the housemaster for a kitchen, formed the "institute" in which Sachs and his students worked. With them were associated G. Kraus, now professor at Halle, and the honored Dr. Thiel,[3] who is still Ministerial-director of the scientific study of agriculture.

The six years of Sachs' activity at Poppelsdorf were extraordinarily rich in scientific results. Fifteen important contributions upon the germination process, upon metabolism and the translocation of food material, upon the influence of light and temperature changes upon particular phases of vegetation, appeared in the years 1862–1864 alone. His work at this time upon the metamorphosis of food material during the germination and early growth of plants demonstrated the easy control of the method of transforming glucose into starch and the reverse, the transformation from carbohydrates into fats, albuminous bodies, etc., and the method of their translocation in the plant body. Although his experiments upon these problems were conducted with the assistance only of the very crude methods of microscopical technique then in vogue, despite our vastly improved methods we are scarcely able to repeat them. But, according to Sachs' own words, the most important outcome of this work was the idea which it prompted, that he must seek the true organs of assimilation in the chlorophyll bodies, a theory which Sachs stated first hypothetically, yet precisely, and which later was established by him through exhaustive research.

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[3] In simple but telling words, full of sincere feeling, this old and true friend of Sachs, at the semi-centennial jubilee of the Academy, told of all those old homely conditions which surrounded the epoch making work of the dead investigator.

Besides these numerous and important contributions there appeared also during the time of his activity as a teacher and investigator at Poppelsdorf the *Handbook of experimental plant physiology*, being part of a general treatise which, at Sachs' suggestion, came out in four volumes, edited by Hofmeister in conjunction with De Bary, Irmisch, Pringsheim, and Sachs. Although Sachs' particular field of physiology has not been the most worked since, the part which he contributed to the *Handbook* is today the best known and most read. On account of its clear method of presentation, and its wealth of striking observations, it yet serves as a valuable source of information. Few of the many observations and suggestions which Sachs made here, with so free a mind, and with such remarkable insight, have been followed up since either by himself or others. The exact physical and mathematical studies of his undergraduate days, the excellent training he had had from Purkinje in the manipulation of physiological experiments, and his remarkably clear and complete method of exposition, united to give to this, his first work of importance, so rare a value that the young docent, known hitherto only for his undaunted energy and manly beauty, gained at once a place of recognition in the world of learning. In humorous vein he once described for me the wonderful "Umschwung" which the appearance of the *Handbook* had gained him.

When De Bary, in the spring of 1867, resigned his chair at Freiburg, Sachs was called to it, and one year later he succeeded

Schenk at Würzburg. Here, where the administration was in fullest accord with the desires of the great investigator, and where he received fullest recognition, Sachs remained thirty years, always hard at work.

During his professorship at Würzburg, Professor Sachs declined calls to high positions at Jena, Heidelberg, Vienna, Dorpat, Berlin, Bonn, and Munich. At Würzburg a great building, which had originally served to house a pharmacological institute, was placed entirely at his disposal for the uses of the botanical institute, since become famous throughout the botanical world, and inseparably associated with the name of its founder. Here were assembled rich collections, excellent contrivances for teaching, and instruments without number, all of which bear eloquent testimony to the emphasis which its director laid upon instruction as well as investigation. "Give your chief attention to your lectures" he wrote to me at Bonn in this connection. "Regard the activity of a professor in the way of publication as a thing of much value for its own sake, and the results as things not to be overlooked, yet always bear in mind that the professor is primarily a teacher." In his laboratory Sachs gathered about him a group of young botanists chosen from the whole scientific world, and the "Arbeiten" of the institute became the recognized authority upon physiological research. Baranetsky, Brefeld, F. Darwin, Detlefsen, Dufour, Elfving, Gardiner, Godlewski, Goebel, Hansen, Hauptfleisch, Heinricher, Klebs, Miliarakis, Millardet, Moll, Müller-Thurgau, Nagamatsz, Pfeffer, Prantl, Reinke, Scott, Stahl, Frau Professor Tarnowski, Vines, H. de Vries, Marshall Ward, Woronin, Wortmann, Zimmermann, and other botanists of renown, have worked at the institute under Sachs' direction.

Only to those who possessed, like himself, the "heilige Ernst" of their subjects were the privileges of the Institute extended. It was hedged about with such rigid restrictions that those who sought the world-renowned establishment for less commendable purposes were distinctly discouraged. Whoever neglected his work, his apparatus, or his plant-cultures (upon plant-cultures

Sachs laid a special emphasis) even once without valid excuse might be perfectly confident that he would find his place occupied by another. There was always a considerable waiting list for entry into the institute. Sachs took only a limited number (ten) of workers into his laboratory, and for my own first appointment as supernumerary in the famous establishment, I have wholly to thank a warm recommendation from Herr Kölliker.

In the first year of his residence in Würzburg, 1868, there appeared the first edition of the well-known *Lehrbuch*, upon which Sachs had begun definite work almost immediately after the appearance of the *Handbuch*, and which was the fruit of years of previous labor in Poppelsdorf and Freiburg. The same evidences of superiority which had already characterized the *Handbook* appeared in yet higher degree in the later volume. Its presentation and general grasp, as well as the vast amount of preliminary research which the work of the author represented, gave the new work a rank which heretofore had never been attained by any text-book of botany. It was a masterpiece of presentation in text and illustration alike, and not only set forth in clear and critical fashion the facts of plant-life which came within its scope, but presented to a considerable extent theories, unworked problems, and the prophecy of future fields which made it invaluable to botanical research. Even more than the presentation and material of the text, the admirable illustrations gave to the work an excellence not yet surpassed. Today we still meet in nearly all botanical texts these excellent old familiar figures of Sachs. Only two years after the appearance of the first edition of the *Lehrbuch*, a second became necessary, and two years later a third, and in 1874 the fourth appeared. In its translated form this book extended the most recent botanical knowledge and the thought of the modern scientific world into all the lands of culture, and it served the interests of physiological investigation and stimulated general botanical interest in a way which heretofore had been denied any botanical work. According to the testimony of my American friends and colleagues, the *Lehrbuch* has worked wonders in the United States.[4]

It is characteristic of the painstaking and thorough nature of his work that Sachs could never bring himself to permit the appearance of a fifth edition of a book which had been so rapidly prepared. "It had become no longer the expression of my ideas," he writes in the preface to his *Lectures upon Plant Physiology*, in referring to the *Lehrbuch*. The *Lehrbuch*, however, had become the court of last appeal in matters of botanical discussion in its particular field, having been more quoted as an authority than any other botanical work.

To the ripened mind of Sachs there had come to be no longer any pleasure in the mere assembling of facts and critical references, which had been necessary in the preparation of the *Lehrbuch*. His artistic nature had prompted the thought that he had a greater work to do in the way of cultivating that feeling toward nature which is so conspicuously lacking in the majority, and which he regarded as essential. With this thought, he devoted himself to the development of a work which was to contain the whole of his botanical grasp and conviction. This was the origin of his *Vorlesungen*, which yet remains the foundation of all investigation in plant physiology. Perfect in its pleasant and vigorous style of presentation, possessing the charm of keen and comprehensive observation, this remarkable work added to these qualities evidences of a master's ideas of artistic work.

A man of a definite and decidedly original conception of things in general, Sachs was able none the less to regard fairly all subjects from other standpoints than his own, a quality which brought him into thorough sympathy with many other fields of work. In one of his lectures he said: "You shall know the process of reasoning whereby your lecturer has formed the mental picture of the field of science which is his personal belief. Your acceptance of it, however, is quite another thing, and whether I am more nearly right than others is a matter which does not enter into the present discussion." The intended function of the *Vorlesungen* was the clear display of a comprehensive picture, confused as little as possible by the universally known facts of plant physiology, and "without the toilsome ballast of apparatus-description, which should be contained in any handbook or text-book published for the profession." Even in the preface to the *Lectures* there is betrayed to the thoughtful observer and psychologist that fine artistic gift possessed by one who was also the keenest and most analytic of investigators.

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[4] See Professor Arthur's address before the American Association for the Advancement of Science, 1895. Proc. A. A. A. S., 7, 9, 15, 17, 18. 1895.

Whoever has had the good fortune to have been intimately associated with Sachs must have noticed the artistic side of his nature. As a boy he was thoroughly instructed by his father in sketching and in painting. A little later, as the student of the younger Purkinje, a highly gifted painter, he became farther imbued with artistic ideas, and as a student at Prague we find him not only upon the benches of the "Hörsäle," but even zealously engaged in the studio work of the Painters' School. Whoever has seen the large and handsome wall-charts which Sachs used in illustration of his lectures, and which he himself prepared, and has watched the rapid and energetic brush work of a hand as fleet as it was sure, must grant that this genial investigator had the ability of a great artist, and might have achieved fame in the world of art.[5]

How very deeply his artistic nature imprinted itself upon his investigations, and influenced his presentation, is expressed in some words which I have found among his unpublished papers:

> With me it has seemed of great importance, and, indeed, has always been a leading thought running through my scientific work, that I should make science as much as possible a work of art, and endeavor in all my publications to use artistic standards in the presentation of the truths of nature. There have been for me, since I began to think independently, no boundary lines between art and nature, and through the course of years I am coming more and more to regard this unity the single goal of my thought. For this

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[5] I recall very clearly how once he had painted a green plant entirely red, and answered my astonished inquiry with the words: "Do you mean that you are unable to detect the red which is in the leaf-green?"

reason every kind of controversy has become distasteful to me, for it gains nothing for progress.

With the idea that it should not be a continuation of the *Lehrbuch*, which had already served but to give a practical insight into the subjects discussed, work on the *Vorlesungen* went on until it had attained a bulk almost too great. Sachs' practical appreciation of the difficulties of his students, and his thoughtfulness for them impelled him to publish with Prantl an abridged edition of the *Lehrbuch*, but later Goebel published the systematic part of the earlier *Lehrbuch* as supplementary to the *Vorlesungen*.

As the result of historical investigation, a critical work far different from that which occupied his chief attention, appeared in 1875, the *History of Botany* from the sixteenth century up to 1860. This work formed the fifteenth volume of an historical series published by the Royal Academy of Sciences of Munich, under the patronage of Maximilian II. Sachs' contribution was a departure from any method which had heretofore been employed in the presentation of the history of botany. His material was not arranged according to authors, nor was it presented chronologically. In this history there again appears evidence of that spirit which never let him feel satisfied until he had made out the entire significance of his facts, their mutual interdependence, and the influences which acted upon the development of botanical study. With his clear presentation of confusing facts, he also furnishes to the reader his own well-founded judgment upon the relative value of different periods. In the preface he wrote:

> I have conceived as my chief task to discover the first awakening of scientific thought, and to follow its later development through comprehensive theories; this is my estimate of the true history of a science. . . . . I have placed here in the foreground as the real makers of our history those men who not only established new facts, but contributed fruitful thoughts as well.

In our judgment, the work of Sachs has been powerful in the construction of what we have called "building material," and he is in the first rank of "geistige" creators. We see him in the last years of his life keen as ever in his scientific contributions, which appeared in the *Works of the Botanical Institute of Würzburg;* and all the time he was successfully engaged in many fields of work, much devoted to the development of new methods and to the contrivance of apparatus, always adding new "Bausteine," that here the edifice of botanical knowledge might be brought to a harmonious completion, and there new foundations might be laid for later superstructure.

And yet, as though in early youth life's bitterest portions had not already been his, he must even in his declining days keep up a hard and bitter struggle for existence. Body and soul, he was during the whole of his life ardently devoted to his work. From four or five o'clock in the morning until late into the night he was at his researches. In his zealous devotion to his work and to his family he blinded himself to the fatal results of the use of the drug to which he had frequent recourse for stimulation. Yet, what Goethe said of his own life, Sachs could say of his, and in full truth, "It was the constant turning of a stone which ever presented itself anew. The annals of my life are ended when that is said. I have too much credit for my activity. It was correlated with my existence."

Sachs was not only a botanist, he was a philosopher in the best sense. His keen and just regard for his own science was lessened no whit by his relation to art and politics and history. The world had for him the same charms and beauties it had for Goethe. Let these words of Goethe be my final tribute to him who was my master and my friend, to whose fatherly regard the warmest feelings of my heart respond:

If he was one who stood apart from the world, let it be called well, for the world can be served best by those who are not of it.

BONN, GERMANY.

NOTES ON THE EUPHORBIAS OF DR. EDWARD PALMER'S DURANGO (MEXICO) COLLECTION OF 1896.

CHARLES F. MILLSPAUGH.

THE following notes, based upon Dr. Edward Palmer's 1896 collection from the neighborhood of the city of Durango, Mexico, while offering but little in the line of novelties, will serve to emphasize the necessity of closer study into the relationship of species in the extensive and intricate genus Euphorbia.

Upon continual comparison of the various species, I have become more than ever convinced that the general habit gives but little insight to true specific character, especially in the Anisophyllæ, and that it is in the seeds only that absolute constancy of character exists. These seeds, minute as they are, retain their specific character even when the general characters of the plant become radically changed by the environment. In regard to the involucres, little can be determined by them except by careful and complete dissection and evisceration of the tubal envelope, the walls and appendages of which only then exhibit their true characters. It would appear that in the typical Euphorbia there are five glands in alternation with five involucral lobes; thus wherever one or more glands are absent in a species some rudiment of these organs remains. This is indicated by the five heavier veins or bands of thickened tissue that lead up from the pedicel to these appendages. While the lobes of the involucre, that play so serious a part in the fructification of the ovule, are constant in their character, the glands and their rudiments, being accessories only, vary much with the habitat and environment of the individual.

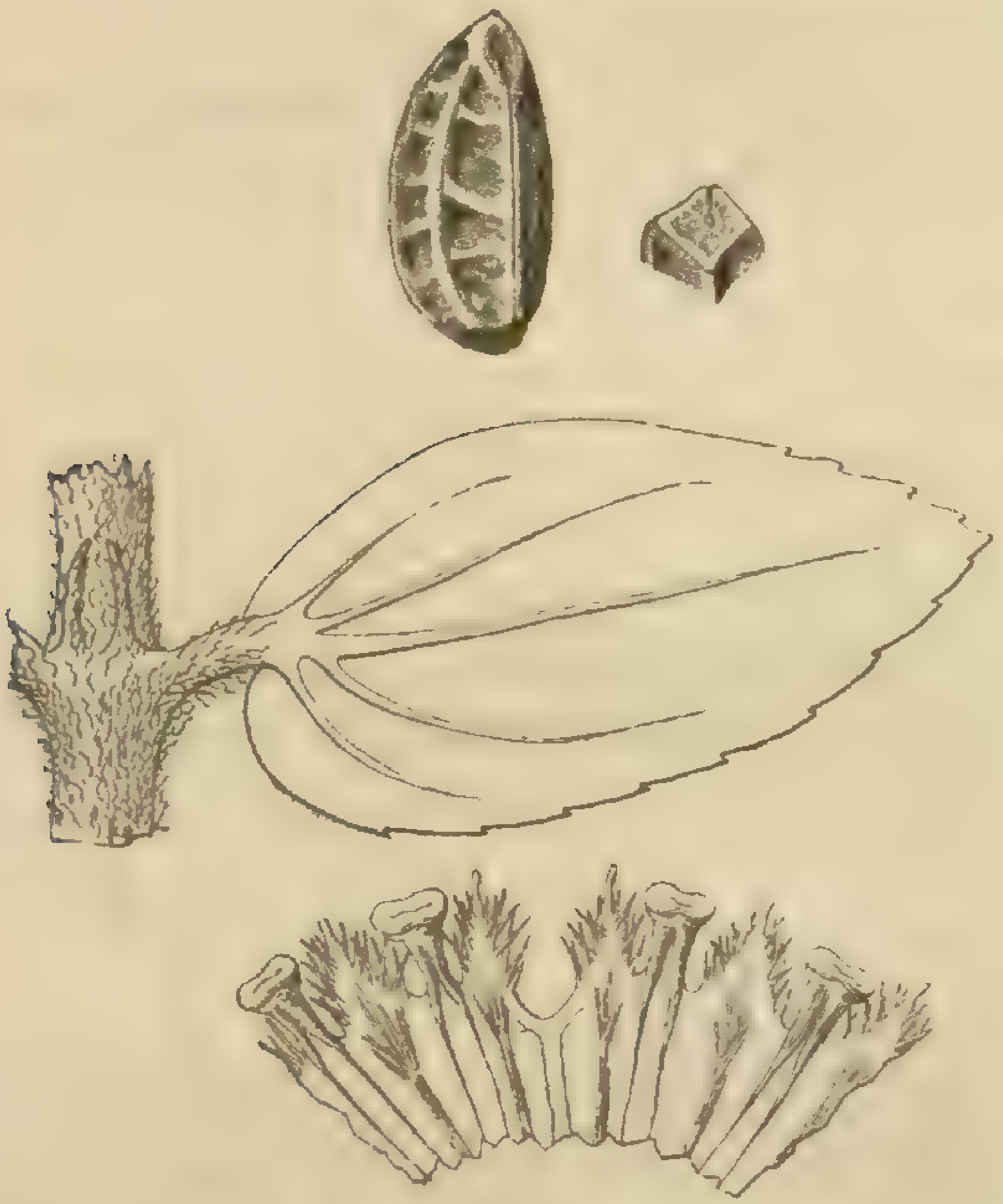
In any series of species the size variation is so great that no specific scale of drawing can be profitably maintained, nor would the invariable application of such scale be of practical value.

Therefore, in the cuts accompanying the species here noted, the opened involucre is diagrammatic, and no size relation exists in the magnified seed.

§ Anisophyllum, *Hypericifoliæ.*

Euphorbia pilulifera procumbens (DC.) Boiss. DC. Prod. 15:21.

In this form the stipules are linear-lanceolate, a pair on each surface of the stem, the superior pair with an interstipular gland. As in *E. lineata* the lobes of the involucre are not "fimbriate," but very hairy; the fact that the hairs are as large as those of the branchlets causes them to appear—in comparison with the minute lobes of the involucre—as if they were fimbriæ. The fifth gland is replaced by a deep notch through which passes the recurved stipe of the fruit. The seeds are pinkish, sharply quadrangular, 0.8^mm^ long, 0.4^mm^ broad, the concave facets marked by several transverse ridges, some of which are extended but part way across the facet.

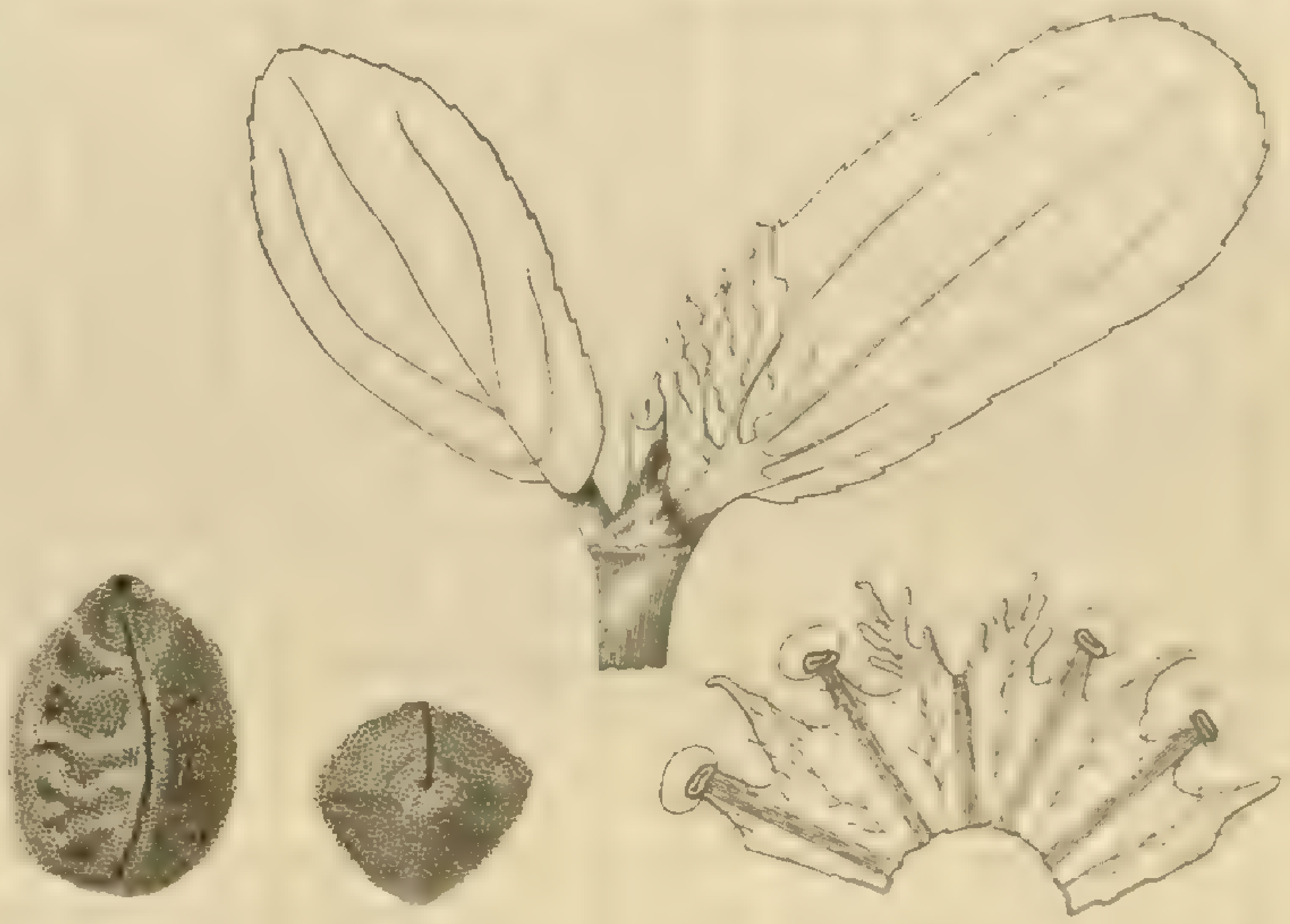


Dr. Palmer's [360 Durango 1896] specimens are the most robust that I have seen. Dr. Schott's Yucatan 56 and 57 are much smaller plants, although the leaves and involucres are of the same size as those in Dr. Palmer's form. Dr. Gaumer's Yucatan 315 is a counterpart of those of Dr. Schott, but his 1003 seems to be a transition to the species itself. Dr. Ridell's Key West 1839 is the same as the Schott Yucatan form, while Valdez Yucatan 2 is very near Dr. Palmer's Durango plants.

Euphorbia Preslii Guss. Fl. Sic. Prod. 1:539.

The various forms of this species throughout its range readily account for its frequent confusion with *E. hypericifolia* L. I have an exact counterpart of Dr. Palmer's 206 Durango in a specimen collected by myself at Waverly, N. Y.; this form has all the leaves large, broad, and lurid. His Durango 894 (similar but with pale green leaves) is duplicated in H. N. Patterson's Oquawka (Ill.) form; while his Durango 900, with its slender and strongly falcate leaves, has its counterpart in Addison Brown's Rhinebeck (N. Y.) and W. C. Werner's Painesville (Ohio) plants. These are all very evident *E. Preslii*, but in a large number of forms from Rio Janeiro to Canada the macroscopic differentiation between this species and *E. hypericifolia* is almost impossible, as the erect or prostrate growth, the smooth or hairy branches, the full or part serration of the leaves, the fimbriation or ciliation of the triangular or lanceolate stipules, the presence or absence of a red spot on the leaves, the size or shape of the glandular appendages or lobes, and the depth of the sulcus bifurcating the styles, intermixes both species in these characters; however, the seed stands out clear and definite in them all, that of *E. Preslii* being ovoid and black, and having a prominent lighter dorsal angle.

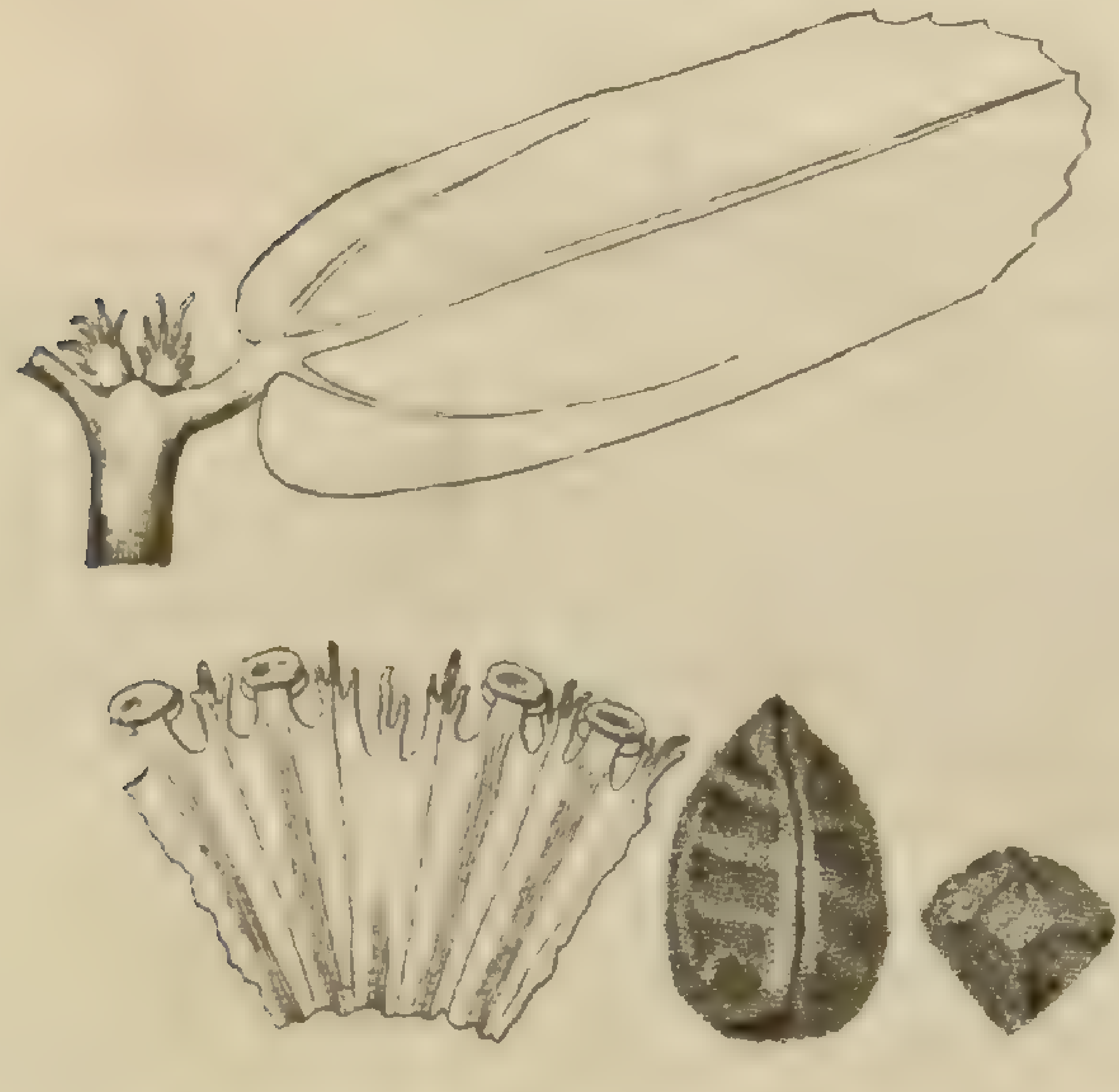
The special characters of this species are as follows: Glandular appendages manifest and entire, the fifth gland replaced by a shallow sulcus flanked on each side by larger and lacerate involucral lobes, the other three lobes being entire and triangular. The seeds are ovoid, black, with somewhat ashen angles, 1.3^{mm} long and 0.8^{mm} broad; the ventral surface is strongly convex, the dorsal triangular with a prominent central ridge rendering the whole sub-quadrangular, the several partly anastomosing transverse ridges on each facet being



slight and ashen. In this and the related species, *E. hypericifolia*, *E. nutans*, *E. lasiocarpa*, and *E. Braziliensis*, there exists a minute black caruncle that appears to have escaped the attention of the authors of the species.

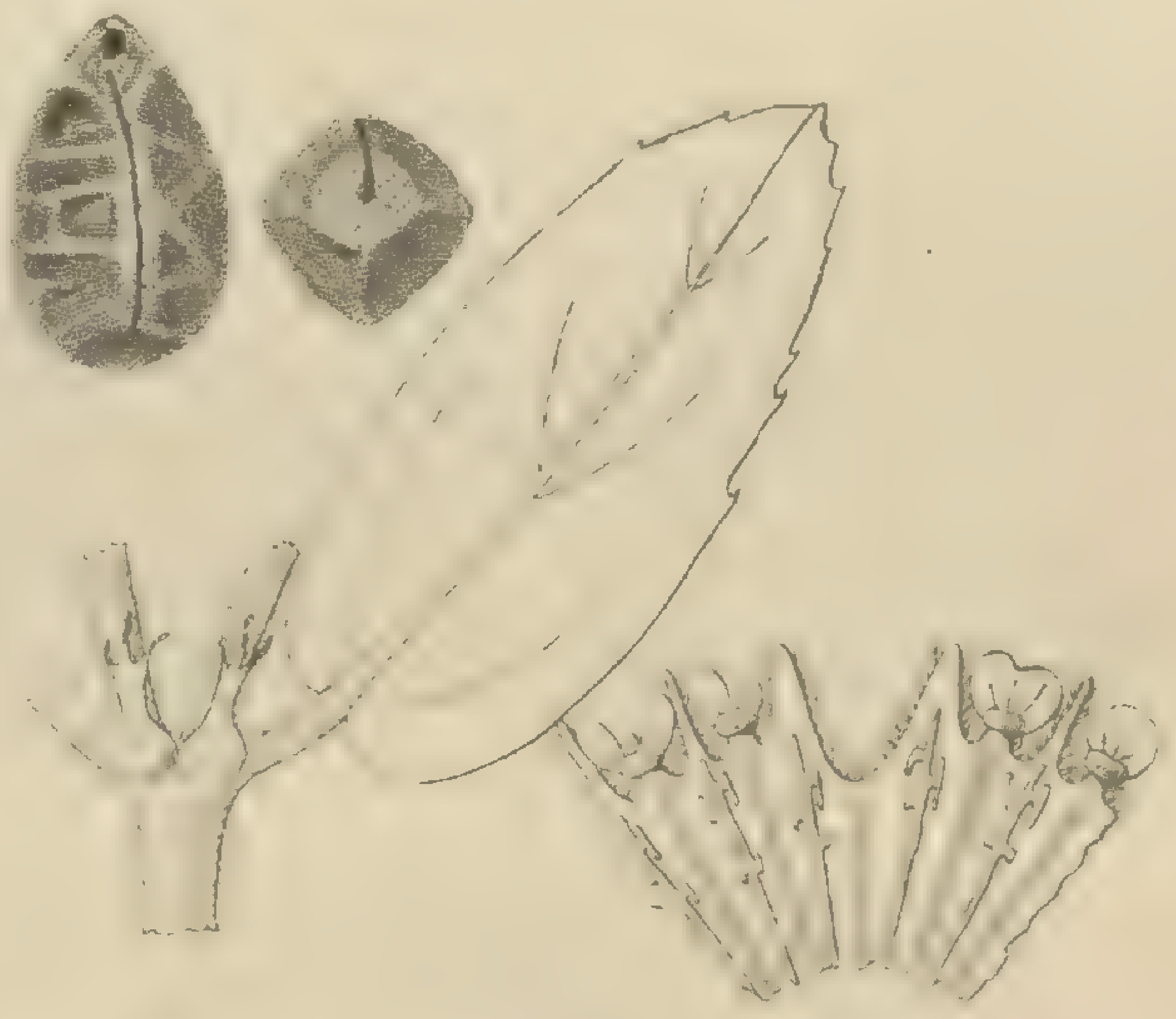
EUPHORBIA NUTANS Lag.? Gen. et. Sp. nov. 17.

In Dr. Palmer's 226 Durango we find a form that answers exactly to Lagasca's species, so far as his meager description gives the characters of his plant. In the absence of his type, I cannot do better than to accept, as a basis of differentiation between it and *E. Preslii*, his "floribus axillaribus solitariis," which cannot possibly mean any known form of the glomerate flowered *E. Preslii*. Lagasca says: "Caule patulo dichotomo villoso: ramis apice floriferis nutantibus: foliis ovato-oblongis subcordatis obsolete serratis: floribus axillaribus solitariis," to each and every character of which Dr. Palmer's plant agrees, except mayhap the "villoso," a character never determinative or constant in any plant. Taking this form, therefore, to answer to *E. nutans* Lag., I add the following to the original description: *Caule patulo dichotomo villoso* at the extremities of the branches only, *ramis apice floriferis*, the upper angulate, the lower striate, the stems terete; *foliis ovato-oblongis subcordatis obsolete serratis* at the apex, 3-nerved; stipules interpetiolar, triangular, long fimbriate-ciliate; *floribus axillaribus solitariis*, involucres small, turbinate, long pediceled; lobes lanceolate, 3 to 4-irregular-fimbriate, glands 4, small, ovate, appendages little more than a sarcous dorsal ridge upon the stipe of each gland, fifth gland replaced by a 2-fimbriate smaller involucral lobe; capsule glabrous, carpels obtuse; seeds ashen-black, the transverse rugæ more prominent than in *E. Preslii*, the ventral suture extending from the caruncle downward, and the dorsal angle sharper.



The determination of this species must be considered provisional.

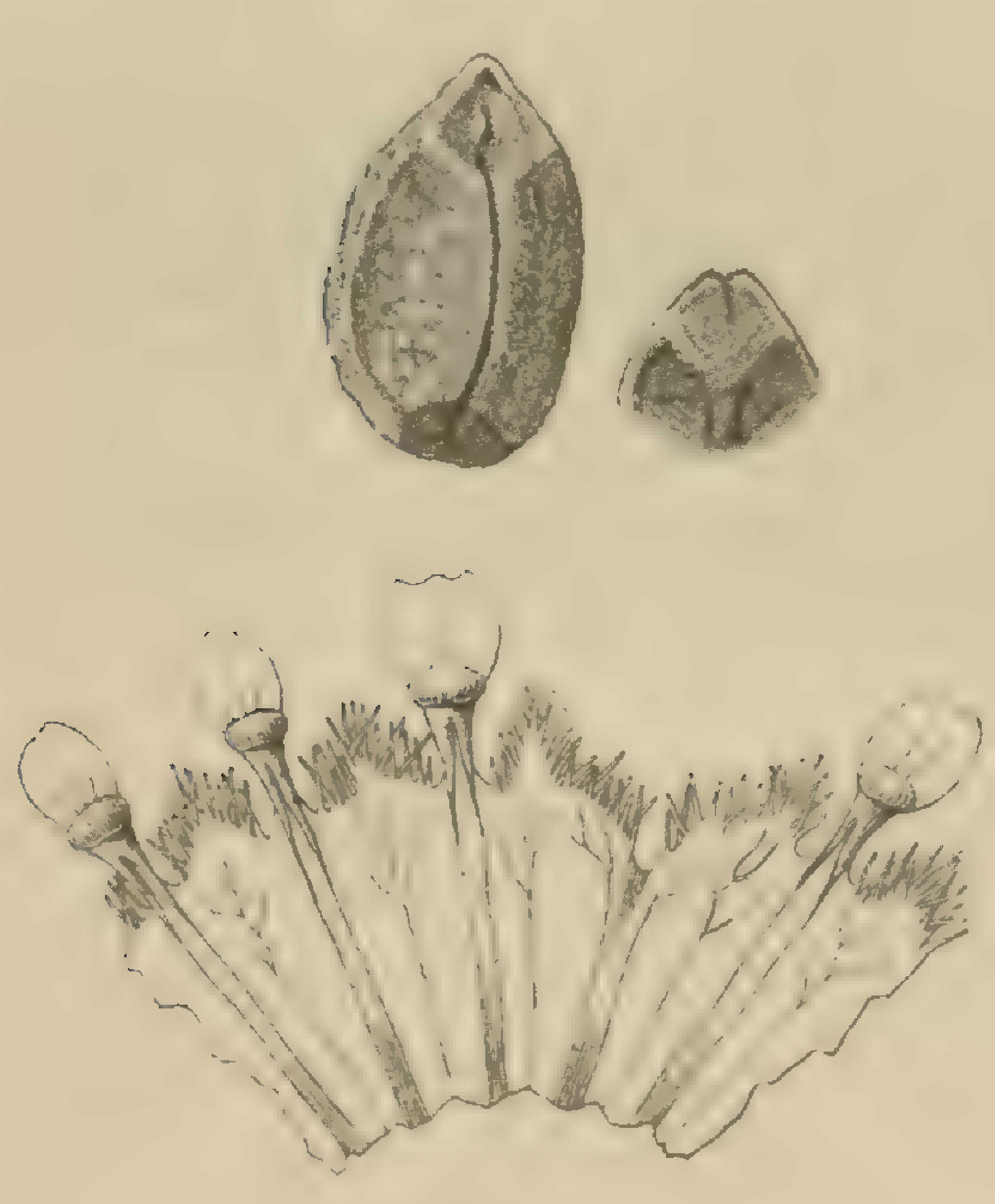
Euphorbia lasiocarpa Klot. Nov. Act. **19**: suppl. 414.



In addition to Boissier's description of this species, in DC. Prod. **15**: 23, might be given the following characters: *Stipulis interpetiol.* roseate beneath, *brevis triangularibus* 2 to 3-fimbriate at the apex. *Semine* brownish red *ovato-quadrangulo*, 1.1^{mm} long, 0.7^{mm} broad, the ventral surface convex, the dorsal triangulo-convex. The anastomosing ridges on facets of this species are much more prominent than in *E. Preslii.* and the angles more obtuse.

Nos. 198 and 199 of my collection (Yucatan Allison V. Armour Exped. 1895) belong to this species, not to *E. hypericifolia* as given in Contrib. **1**: 27, Field Col. Mus. Bot. Dr. Arthur Schott returns the species from Merida, and Dr. Gaumer from Izamal (882), Yucatan

Euphorbia lineata Watson, Proc. Am. Acad. **21**: 455.



Leaves short petiolate, more crenate than serrate, stipules lanceolate-aristate on the upper side of the branch, lanceolate-fimbriate on the under side. The involucral lobes of the type are not "lacerate" but triangular-hairy, the hairs appearing like lacerations, the glandular appendages are small, oblong entire or 1 to 3-notched at the apex. The fifth gland is represented by a deep sulcus between the two larger involucral lobes. A distinctive feature in this species is the presence of glands at each bifurcation of the panicled inflorescence, large counterparts of the involucral glands.

Dr. Palmer's 618 Durango specimens differ from the type in their somewhat larger appendages, longer and more hairy petioles, and more robust habit.

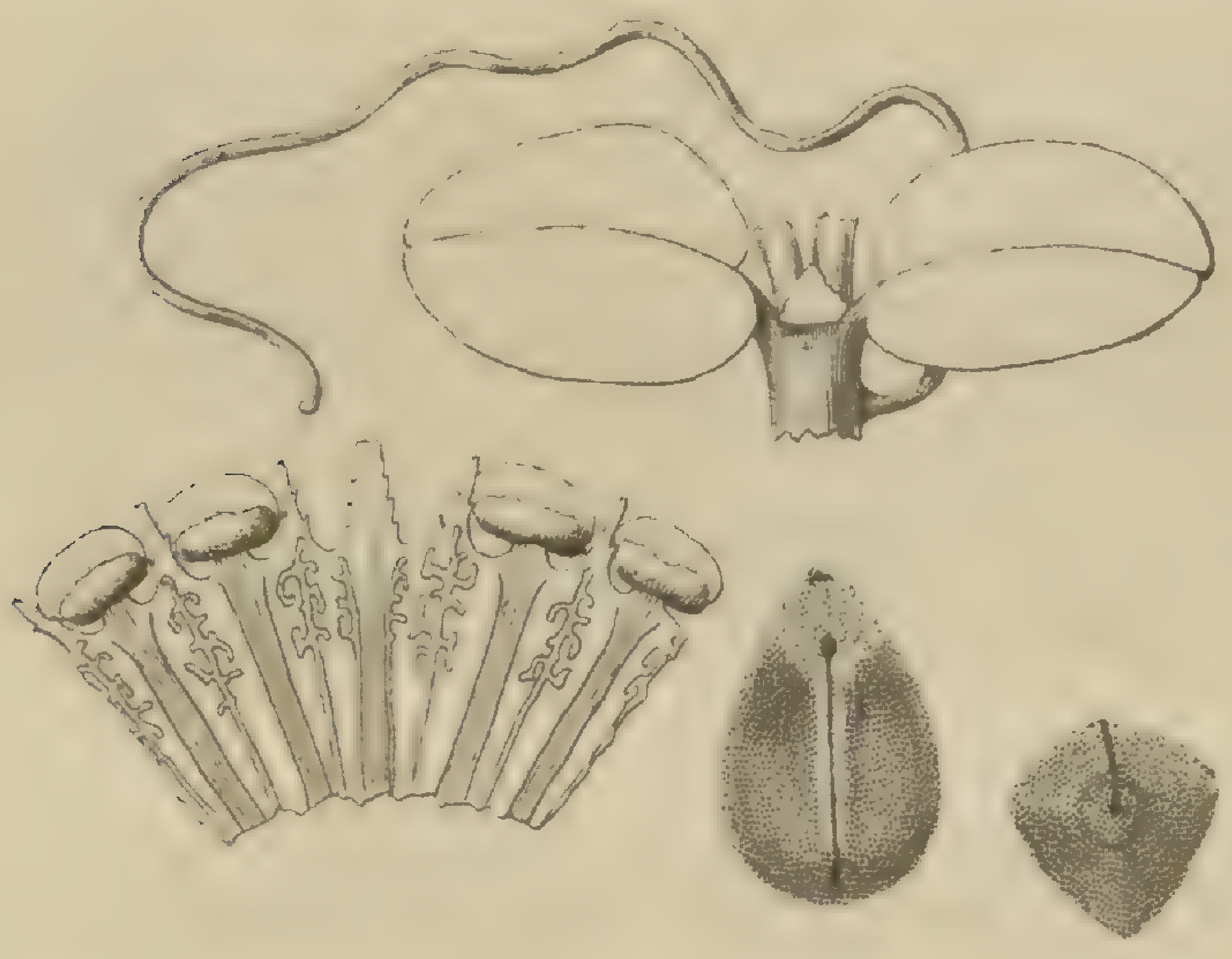
Chamæsyce.

E. SERPENS Kth. H. B. & K. Nov. Gen. et Sp. **2**:41.

Dr. Palmer's 42 Durango specimens of this species are very close to var. *radicans*, but the appendages are plainly to be seen. The stipules are interesting, those of the extremities of the branches being roseate and longer than the floral leaves, those of the lower leaves being subtended by a small peltate-stipitate gland or pair of glands, a feature also present in Pringle's 3778 from San Louis Potosi, 1891. Dr. Palmer also returns from Durango (819) a small rosulate-prostate form with minute leaves, and a general roseate color.

EUPHORBIA SERPENS RADICANS (Moric.) Engelm. DC. Prod. **15**: 30.

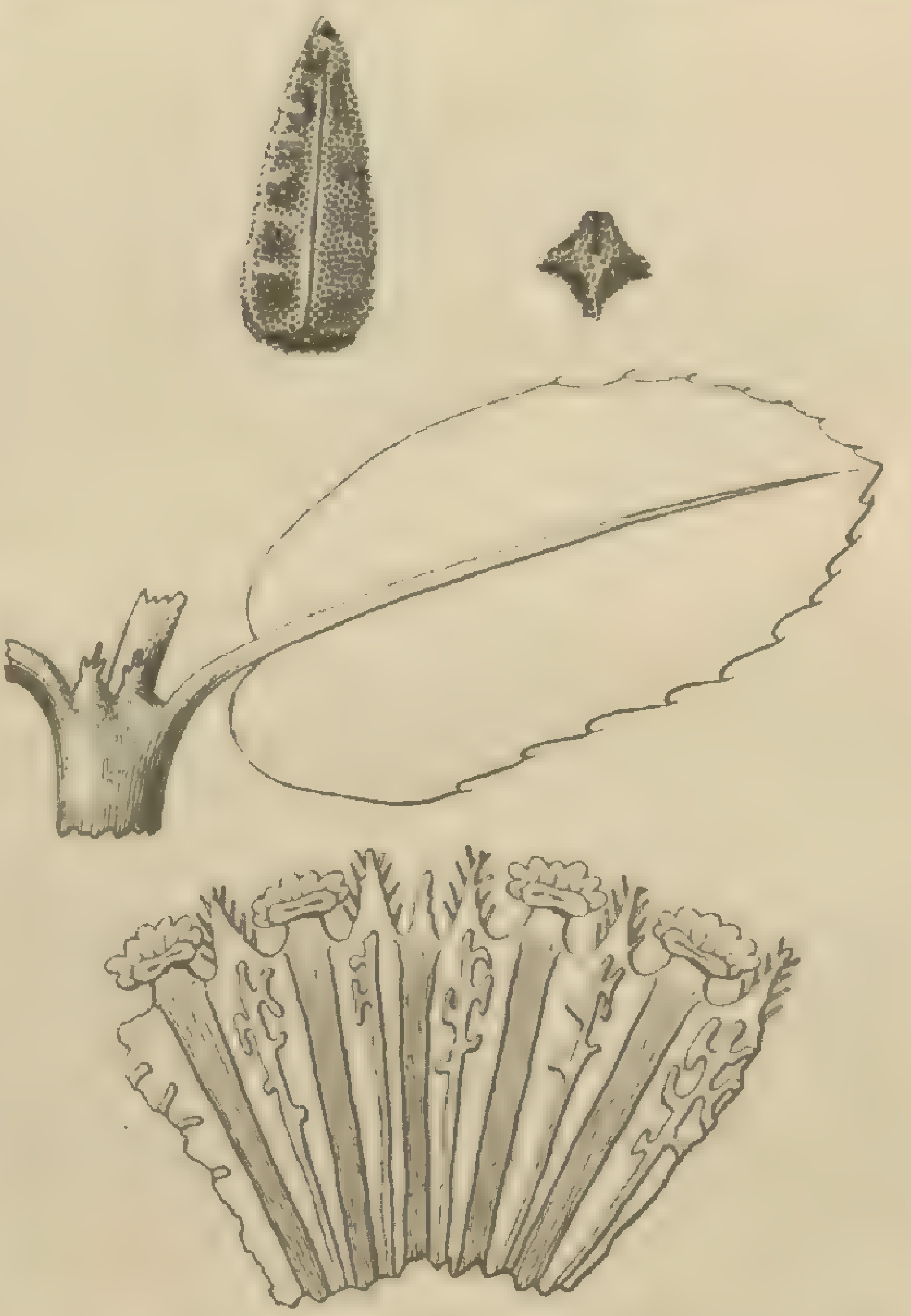
In *E. serpens* and its forms the fifth gland of the involucre is replaced by a truncate serrate lanceolate lobe. The venation of the involucre throughout the *Chamæsyce* is interesting, as by its size and maze-like character it plainly shows this body to be evolved from the leaf, where this venation is continued in an anastomosing network of the same elemental type. The seeds are pink, somewhat pyriform, 0.8^{mm} long, 0.5^{mm} broad, triangular with a convex ventral surface, and sharp dorsal angle.



Dr. Palmer's 296 Durango, fine robust examples, have red-maculate leaves, frequent radication towards the ends of the branchlets, nearly entire (simply erose) stipules and exappendiculate glands. Specimens collected by Dr. Mohr. and Newman in Alabama agree well with Dr. Palmer's, while those of Pammel from Iowa, Eggert from Illinois, Dr. Krause from Missouri, and myself from West Virginia have very evident white or roseate glandular appendages, and fimbriate-margined stipules.

EUPHORBIA PROSTRATA Ait. Hort. Kew. **2** : 139.

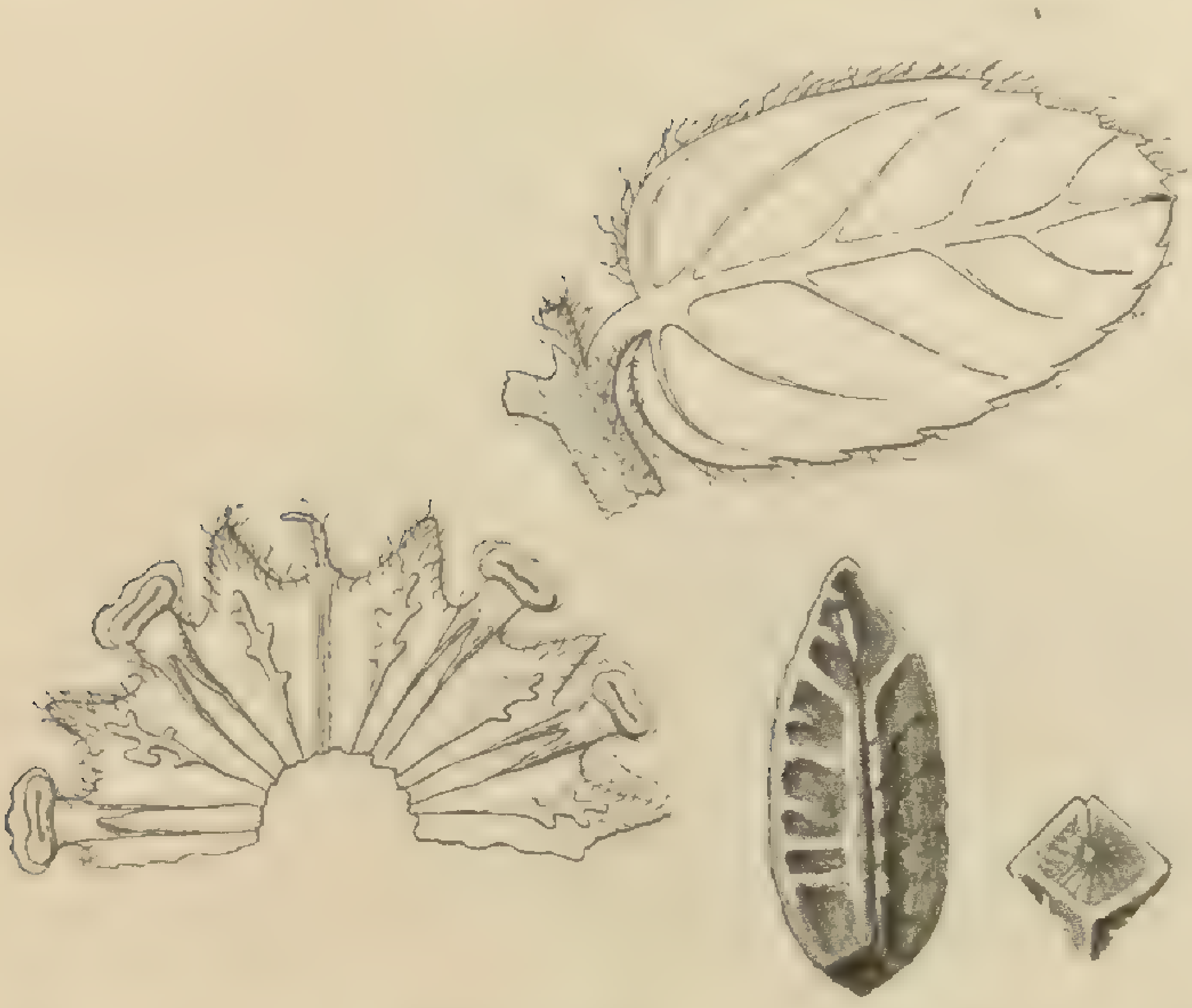
Dr. Palmer's Durango specimens of this species agree with the description of Boissier in DC. Prod. **15** : 47, except in having appendages as long as the width of the gland, and 3–several round-dentate on the margin. In this species the fifth involucral gland is replaced by a small triangular-entire sixth lobe, the stems are striate, and the leaves denticulate all along the lower, and for one-half the upper margin. The seeds are pink, strongly tetragonal, narrowly elongate-pyriform, 1.5$^{\mathrm{mm}}$ long, 0.6–7$^{\mathrm{mm}}$ broad, and have all the facets concave and traversed transversely by numerous anastomosing rugæ.



In Dr. Palmer's 897 the leaves are larger and all parts except the involucres more robust than in his 225, in which nearly all the leaves are of the character of the minute floral leaves in the first.

EUPHORBIA STICTOSPORA Engelm. Mex. Bound. Bot. 187.

The triangular involucral lobes of this species are not "profunde fimbriatis" but densely hairy, the hairs being of the same size and structure as those of other parts of the plant. The fifth

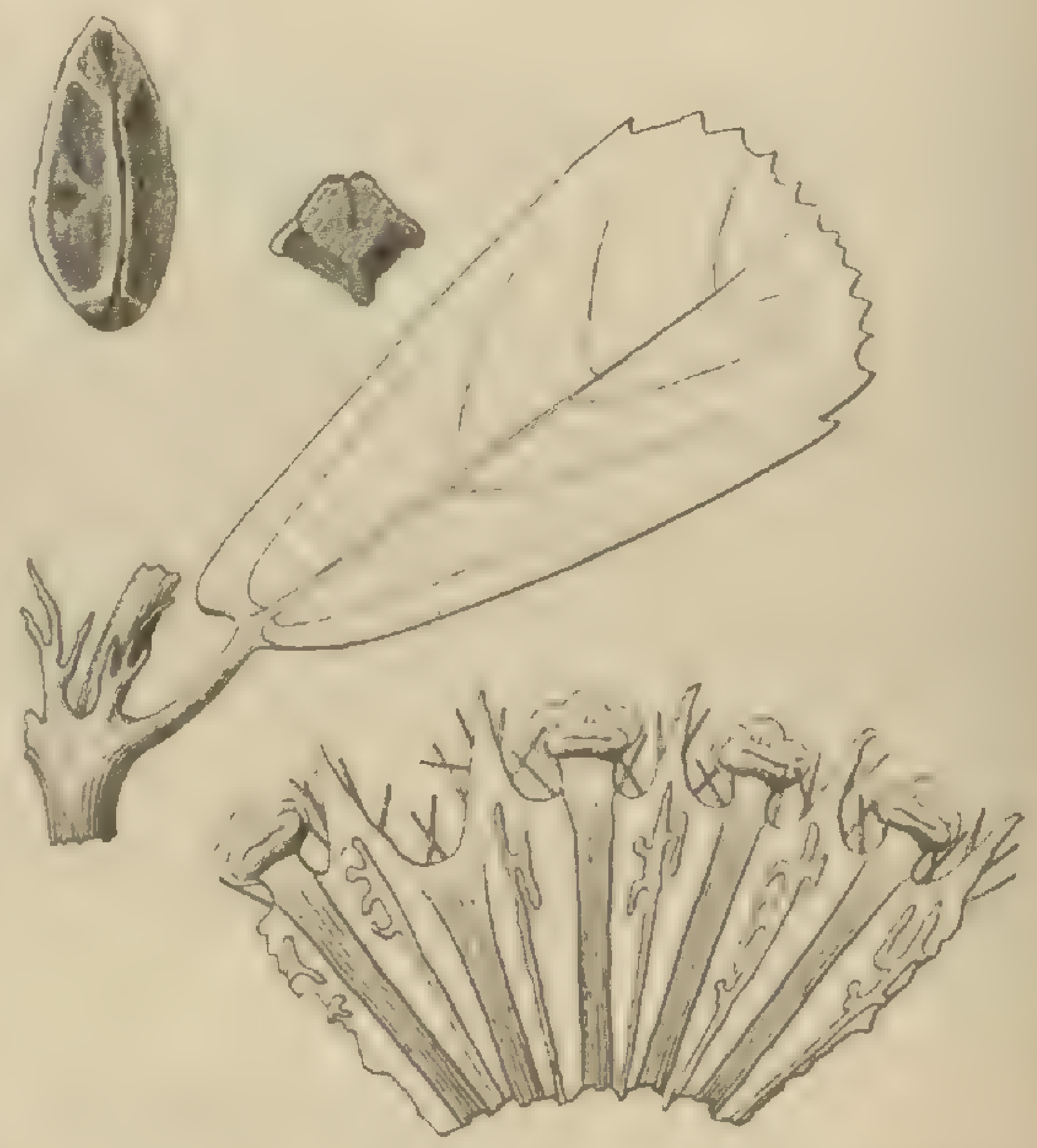


gland of the involucre is replaced by a triangular-linear sixth lobe. The involucre is more subcylindrical than turbinate. Seed ashen, somewhat falcate laterally, elongated-tetragonal, 1.4^{mm} long, 0.5^{mm} broad, the ventral facets concave, crossed by several prominent regular rugæ; the dorsal facets plane, densely covered by prominent irregularly anastomosing rugæ.

Dr. Palmer's 43 Durango specimens agree with the type, and are counterparts of Pringle's 80 Jimulco Valley, and 1076 plains of Chihuahua.

Euphorbia serpyllifolia Pers. Ench. Bot. **2**: 14.

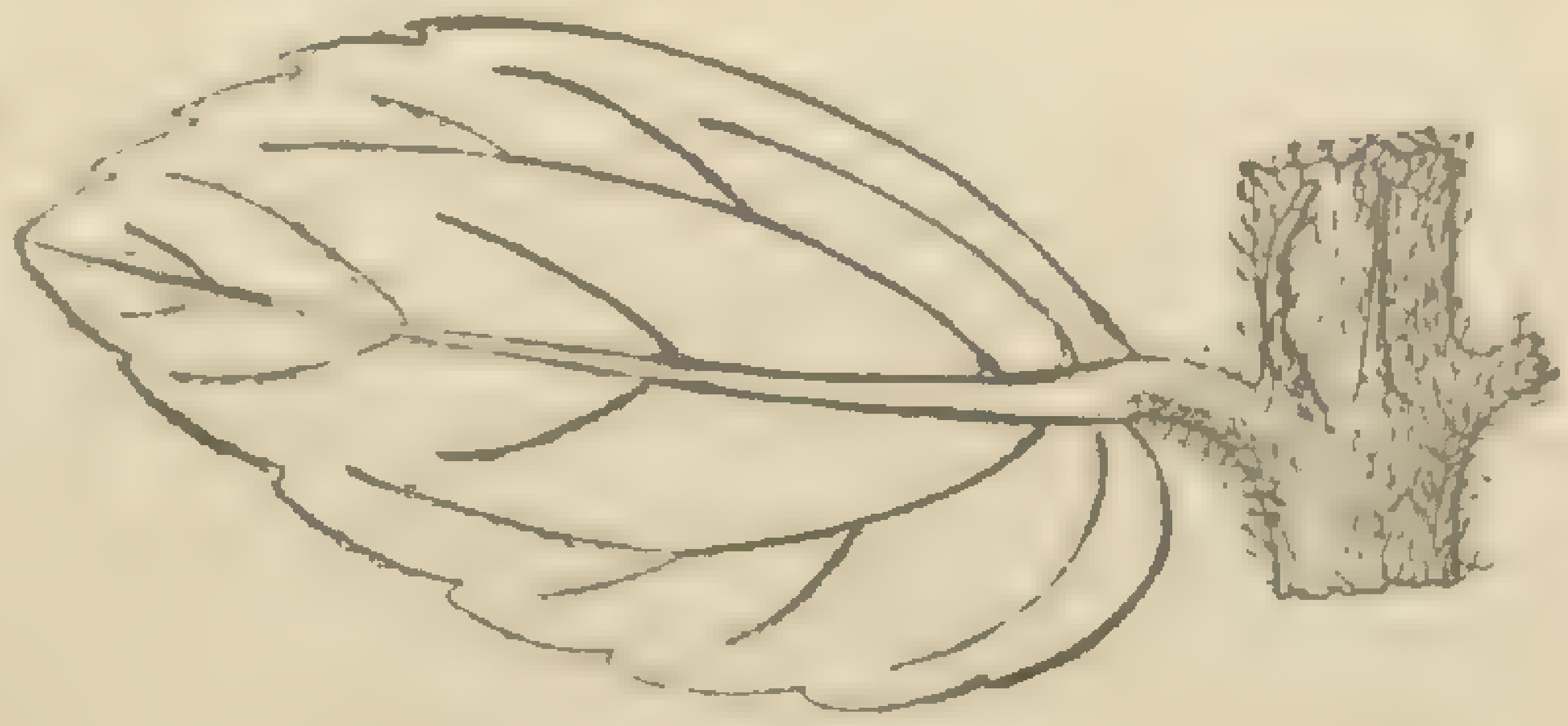
This species is readily distinguishable by its truncate-serrate leaves. The fifth gland of the involucre is represented by a truncate sulcus between two enlarged involucral lobes. Seeds ashen or amber-color, 1.1^{mm} long, 0.6^{mm} broad, strongly tetragonal; the facets of the ventral surface concave, marked by a few indistinct rugæ; those of the dorsal surface convex, rugæ anastomosing, and somewhat more evident.

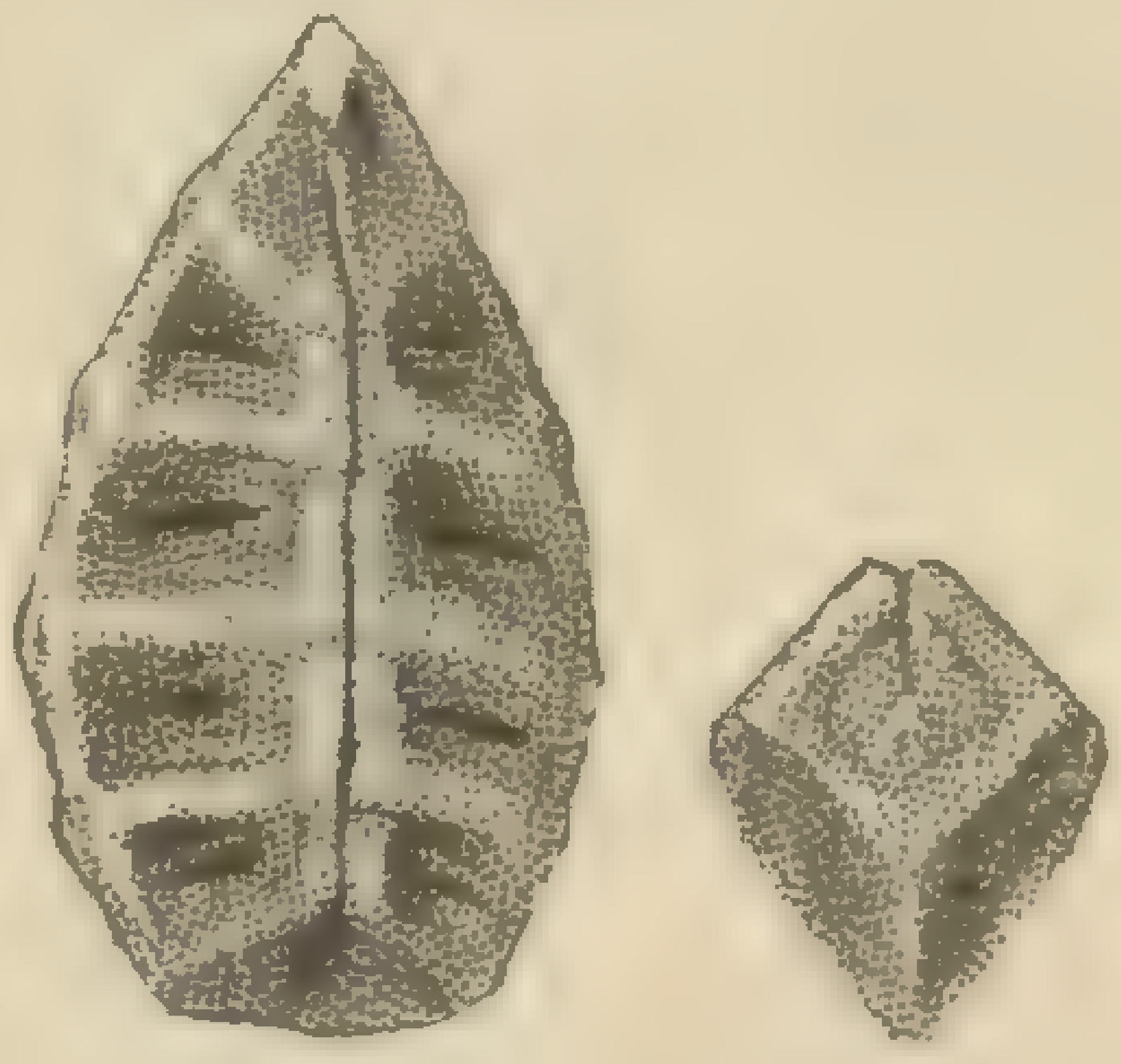


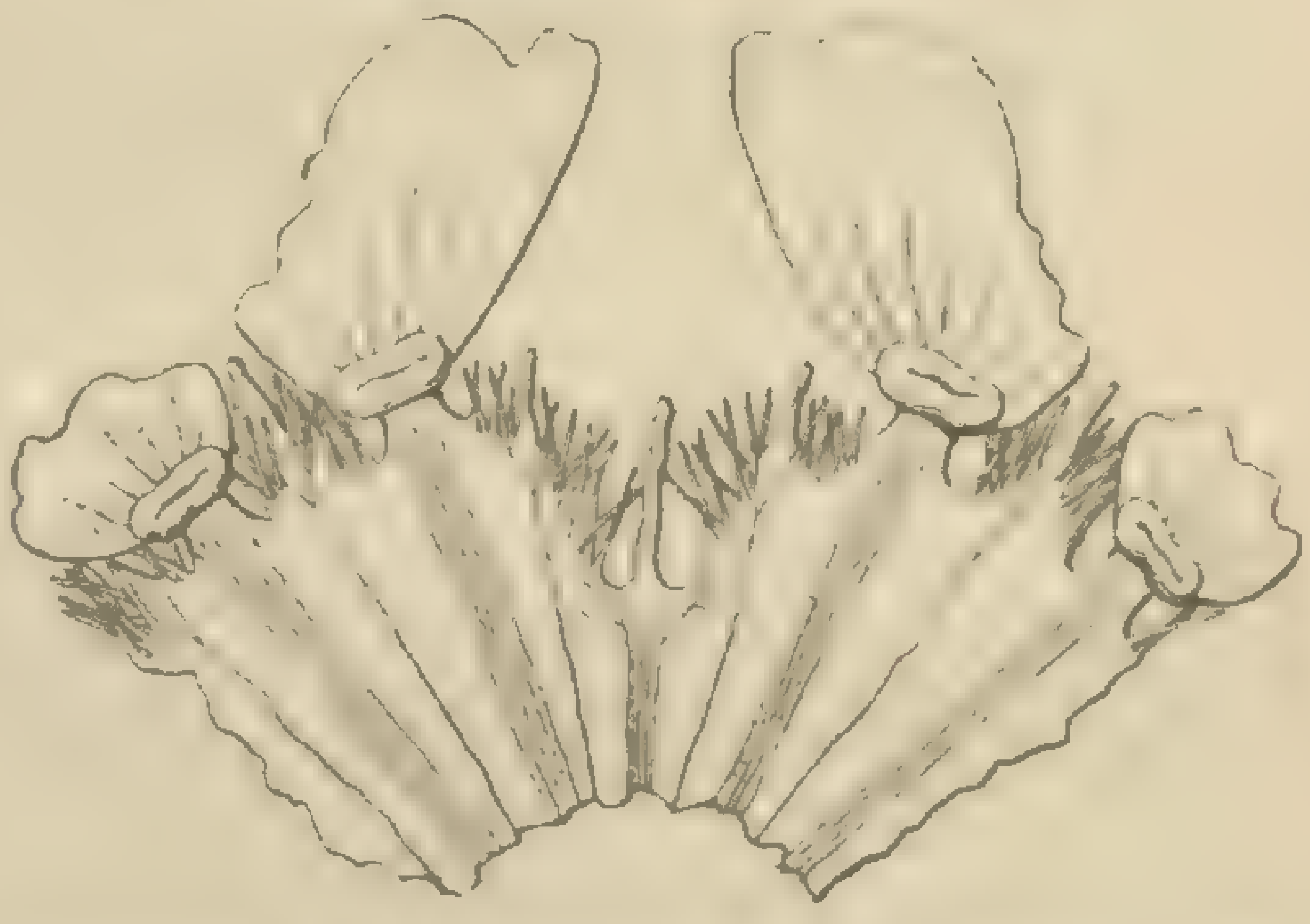
In Dr. Palmer's 899 Durango the involucres are externally hairy, otherwise—though robust in habit—his specimens agree with the type, and with E. L. Greene's Bear creek (Colorado) and M. E. Jones' 3998 Flagstaff (Arizona).

Euphorbia adenoptera Bertol. Misc. Bot. **3** : 436.

In this species a deep cleft replaces the fifth involucral gland which is also represented by a linear sixth lobe, otherwise the involucre is not "profunde fissis." The involucral lobes are more linear than "lanceolatis." The seed is pinkish-white, strongly tetrangular, 1^{mm} long, and 0.5^{mm} broad, all the facets plane and deeply scored by four or five transverse pits, the ridges separating which are projected to include the angles of the seed.





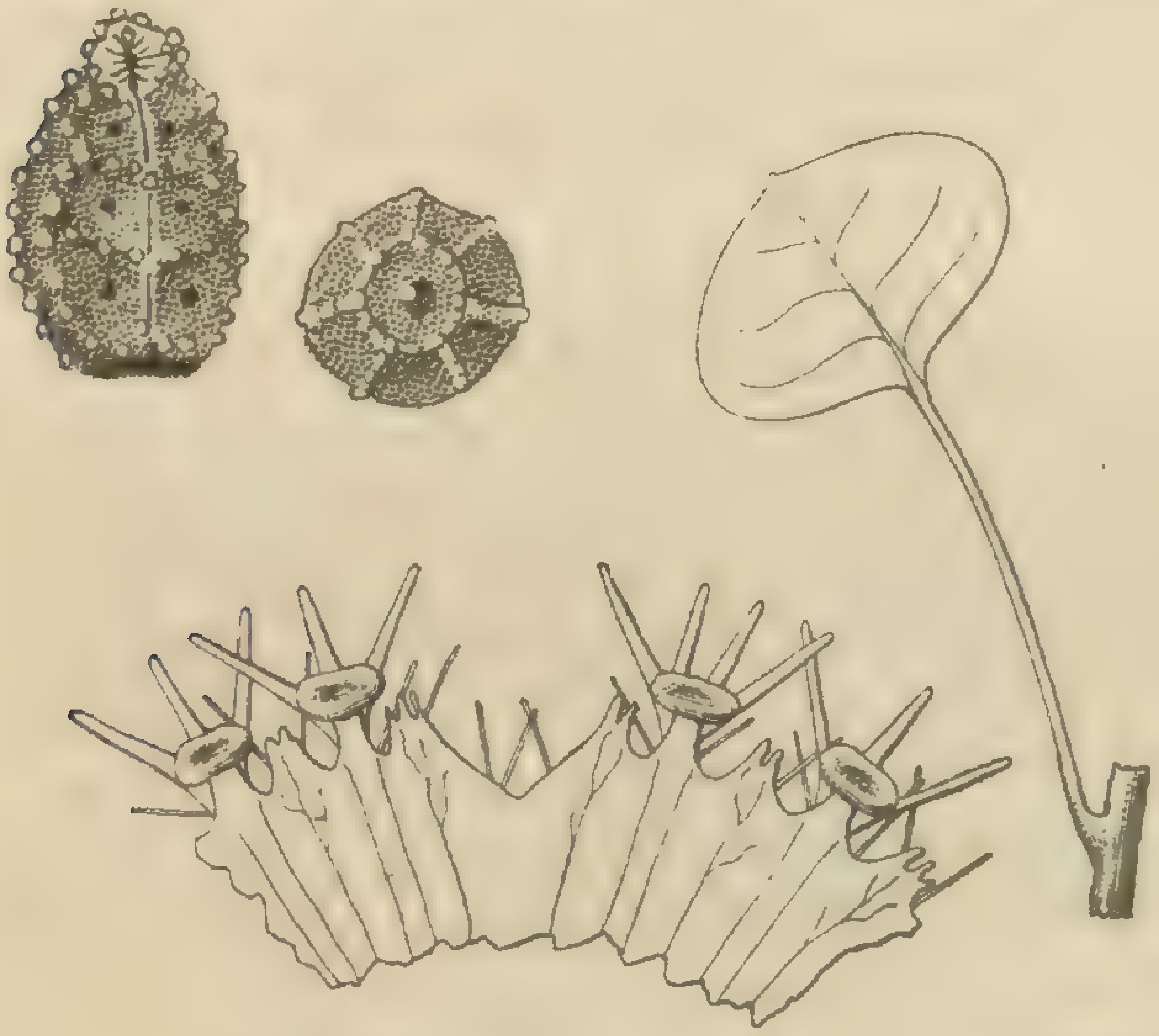


Dr. Palmer's 898 Durango agrees exactly with a part of J. G. Lemmon's Rucker valley and Churricahua mountains (Arizona) specimens. All these might be termed *forma rosea*, as the appendages and glands are so deep a red as to give the whole plant a roseate appearance. My Chichen Itza Yucatan 107 Allison V. Armour Exped. specimens are also of this form, but differ in having all the stem leaves narrowly lanceolate like the intrafloral leaves of the usual form. Dr. Arthur Schott's 966 Sisal, Yucatan, is apparently a transition from the last to the first form, while Dr. Gaumer's 938 Izamal is more markedly like the Durango form, his specimens being the largest I have seen; his 939 Sitilpech is, however, a very straggling open growth with long virgate branches.

§ Cyttarospermum.

Euphorbia subreniforme Watson, Proc. Am. Acad. **21** : 439.

In this species the fifth involucral gland is represented by a

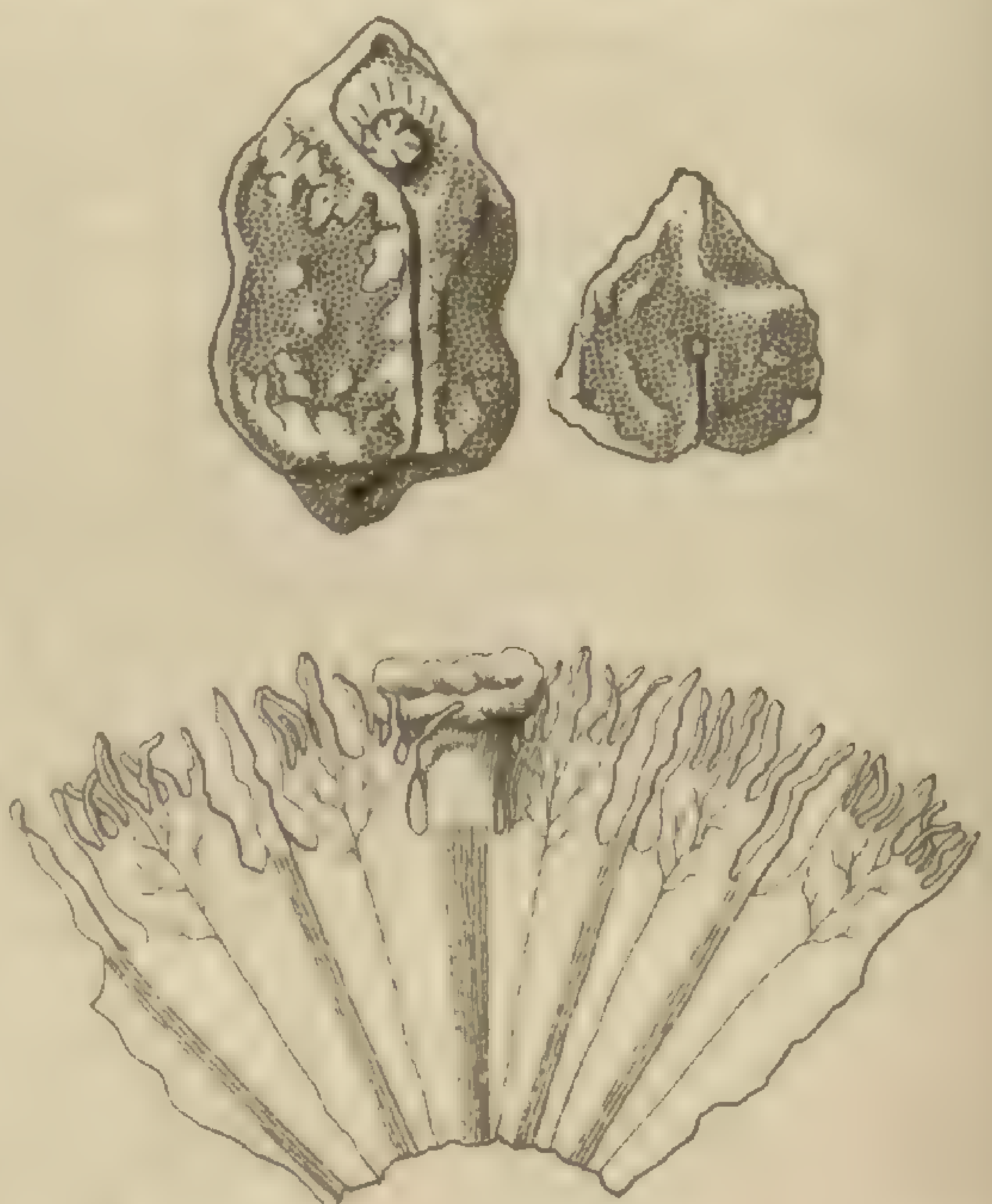


deep triangular sinus flanked by unaltered lobes. Involucral lobes 2–4-irregular toothed (not entire, ciliate, as described). Walls of the involucre thin-membranous, columnæ wanting, external hairs few, setose. Seed ashen, globular-pyriform, 1.1^{mm} long, 0.8^{mm} broad, the facets marked by 3–4 shallow punctate pits deepened by tuberculate dividing ridges, the tubercles tipped with an amber-colored mucilaginous accretion.

Dr. Palmer's 896 Durango agrees fully with C. G. Pringle's 2063 and 2302 Jalisco specimens.

§ Poinsettia.

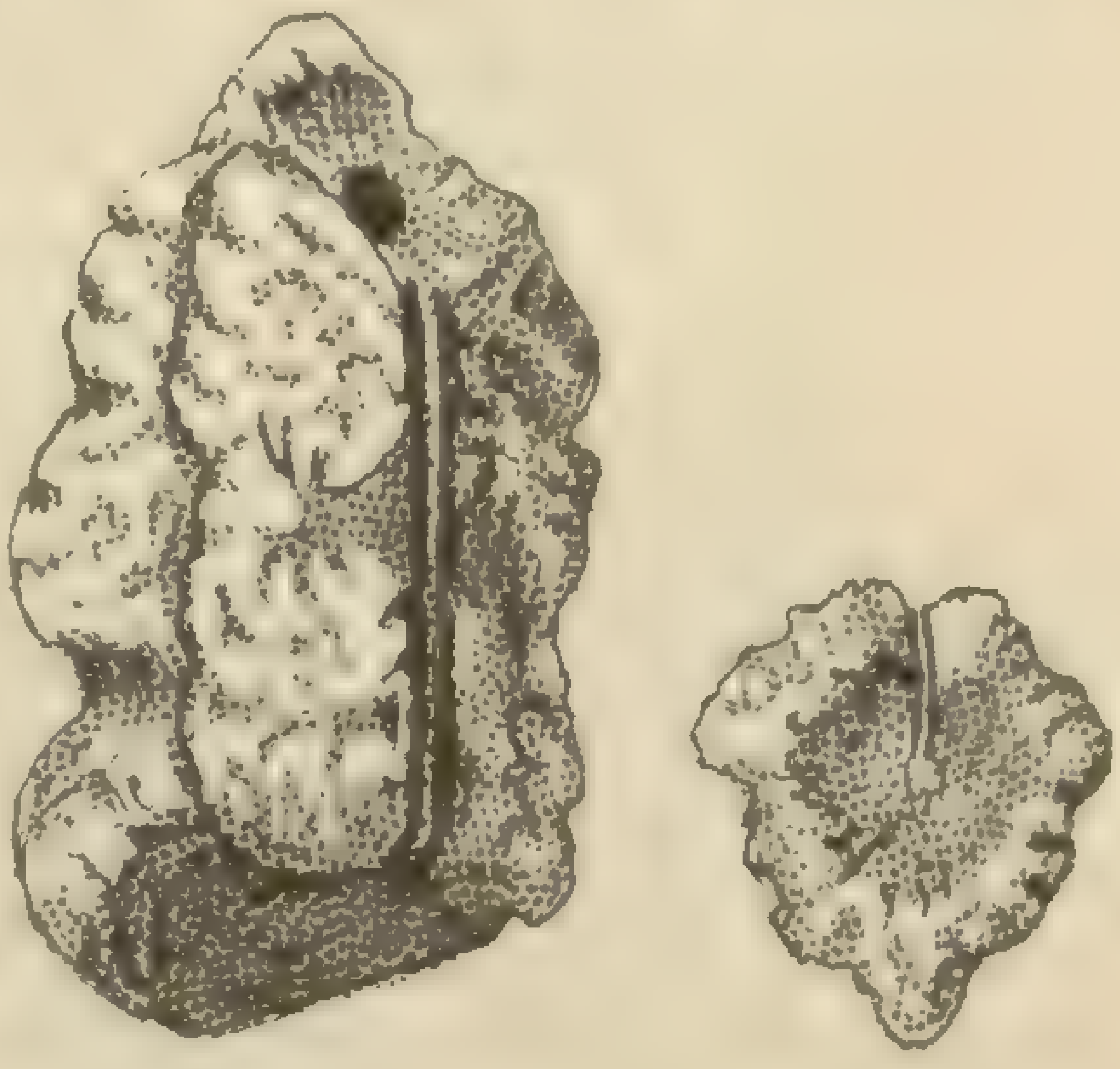
Euphorbia dentata lasiocarpa Boiss. DC. Prod. **15**: 72.



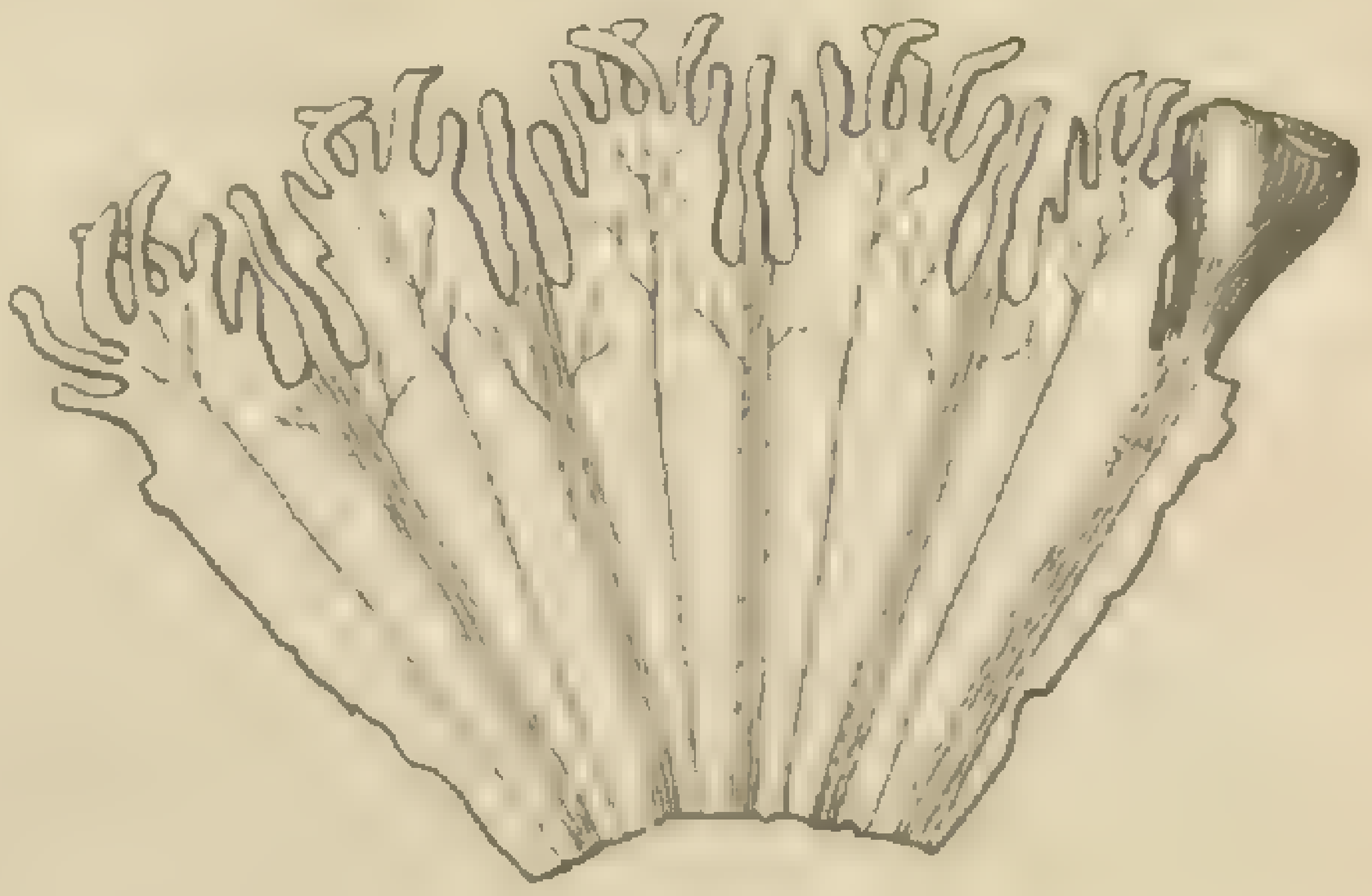
In this form and in the species as well, the involucral lobes are not dentate as described, but long-fimbriate. The four missing glands are replaced by an equal number of linear involucral lobes. Seeds dark reddish-brown, 2.4^{mm} long by 2^{mm} broad, sharply triangular in section, the facets, especially those of the dorsal surface, roughly white tuberculate.

Dr. Palmer's 660 in part and 895 Durango specimens are the most usual form of this variety.

Euphorbia heterophylla graminifolia (Michx.) Engelm. Mex. Bot. 190.

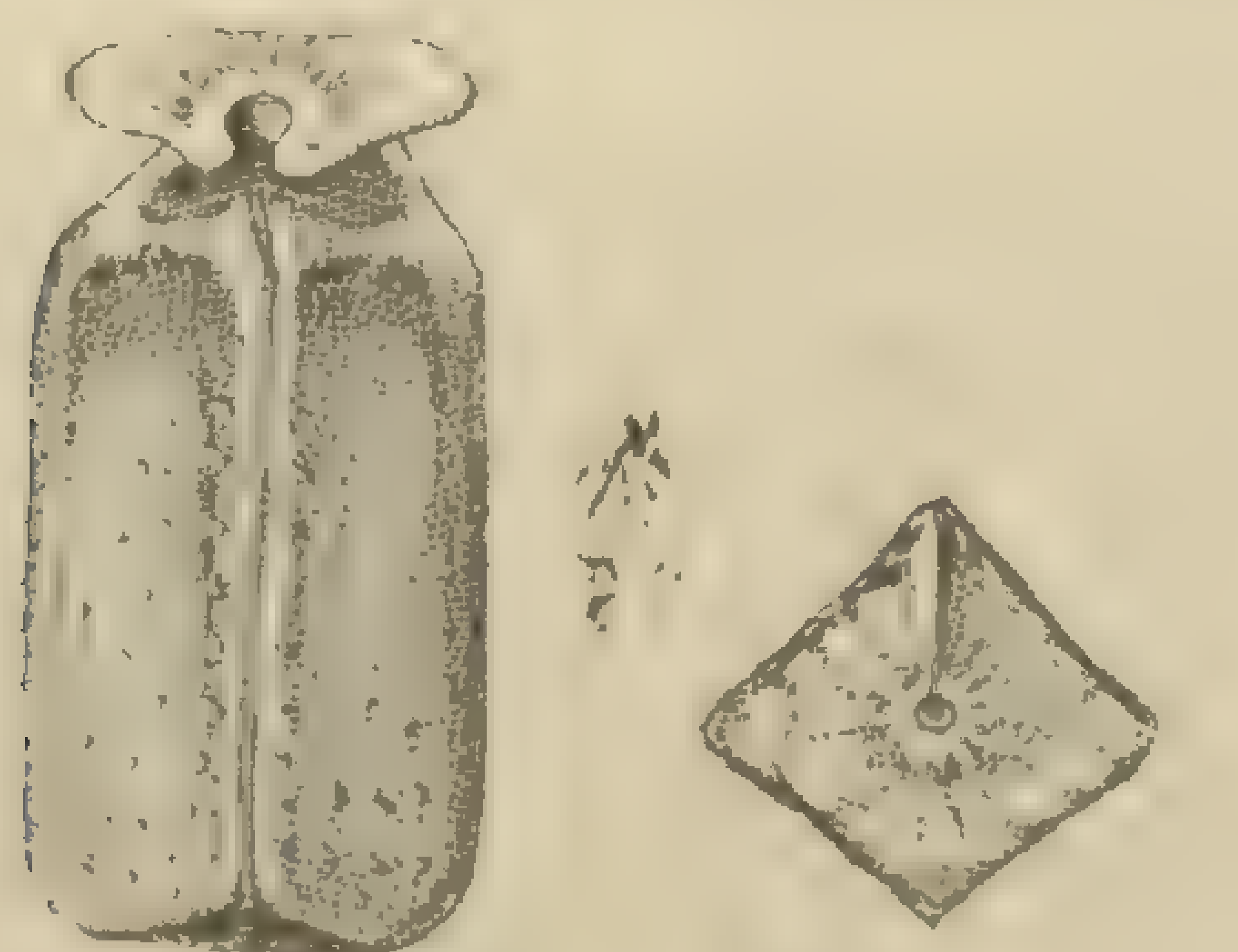


Dr. Palmer's 659 Durango is the typical form of this variety, the lower leaves being scabrous above, and strigose with long scattered hairs beneath. The four missing involucral glands are represented by a like number of linear lobes. The seeds, instead of being lenticular in section as in the species, are even more sharply triangular than in var. *eriocarpa* Millsp.

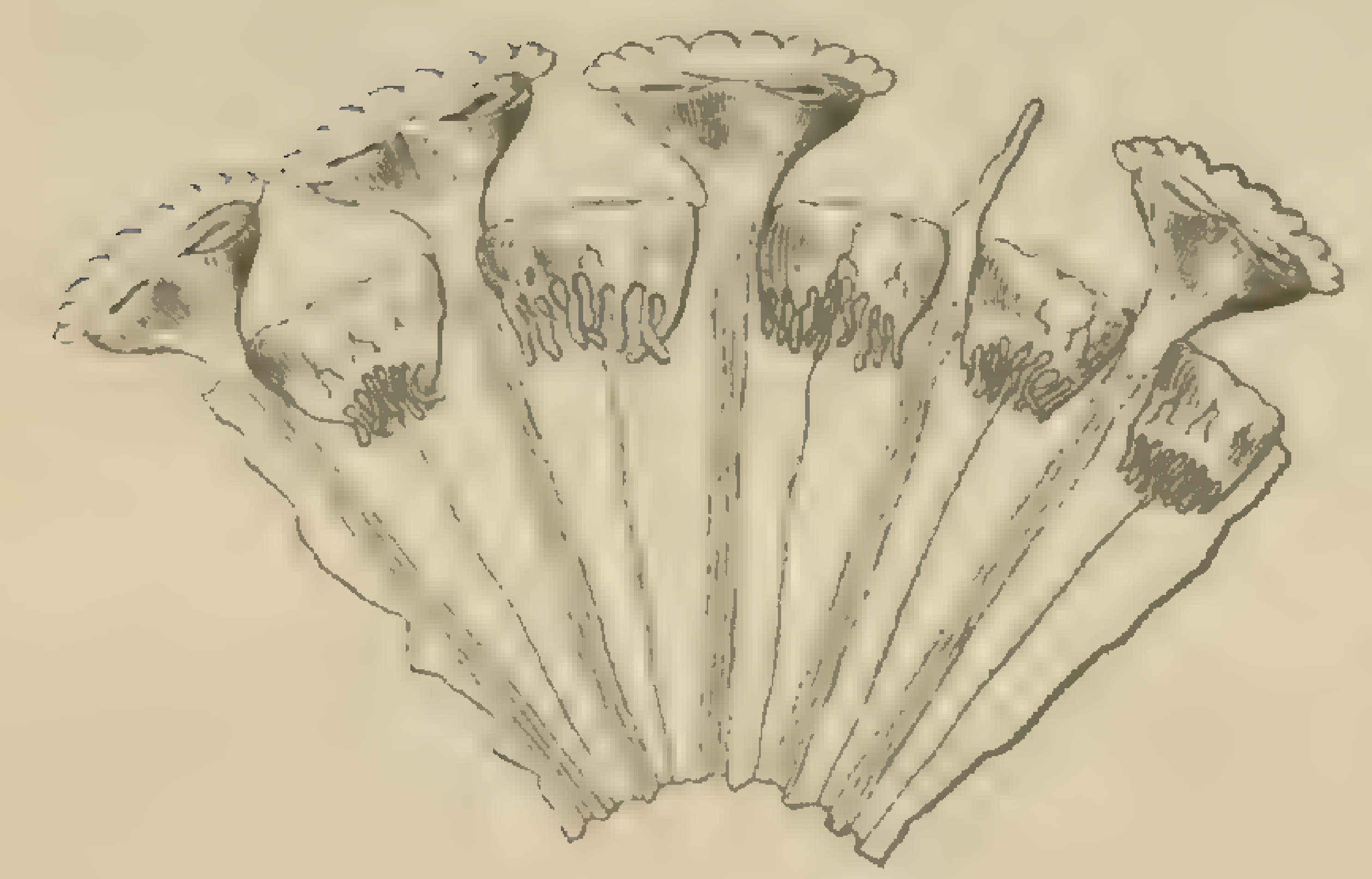


Euphorbia Jaliscensis Rob. & Greenm. Proc. Am. Acad. **29**: 392.

Dr. Palmer, in his 660 (in part) Durango, rediscovers this interesting species, first collected in the barranca of Tequila by Pringle (4608) in 1893. His specimens agree with the type except that they are less robust in habit; notwithstanding this the leaves show still more clearly their sessile character.



In this species the leaves tend rather to be acute than obtuse; although apparently "winged petiolate," the dilation of the wings at the juncture with the stem, and their continuation above with the leaf, proves them sessile. The glands are stipulate, with appendages 8–12-crenate-dentate. The fifth involucral gland is represented by a linea blunt lobe. The involucral lobes are strongly



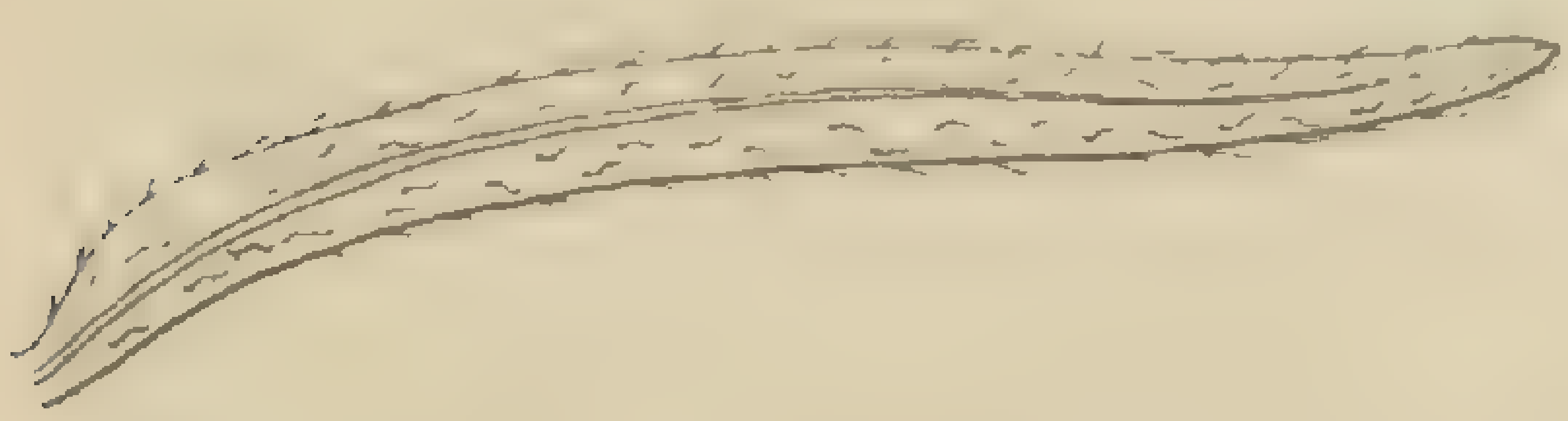
incurved. The striking columnar dark seeds are almost perfectly tetragonal, 4.5^{mm} long, and 2^{mm} broad, with the concave ventral facets slightly papillate; the caruncle is large, stipitate, and shaped like a water-carrier's neck yoke.

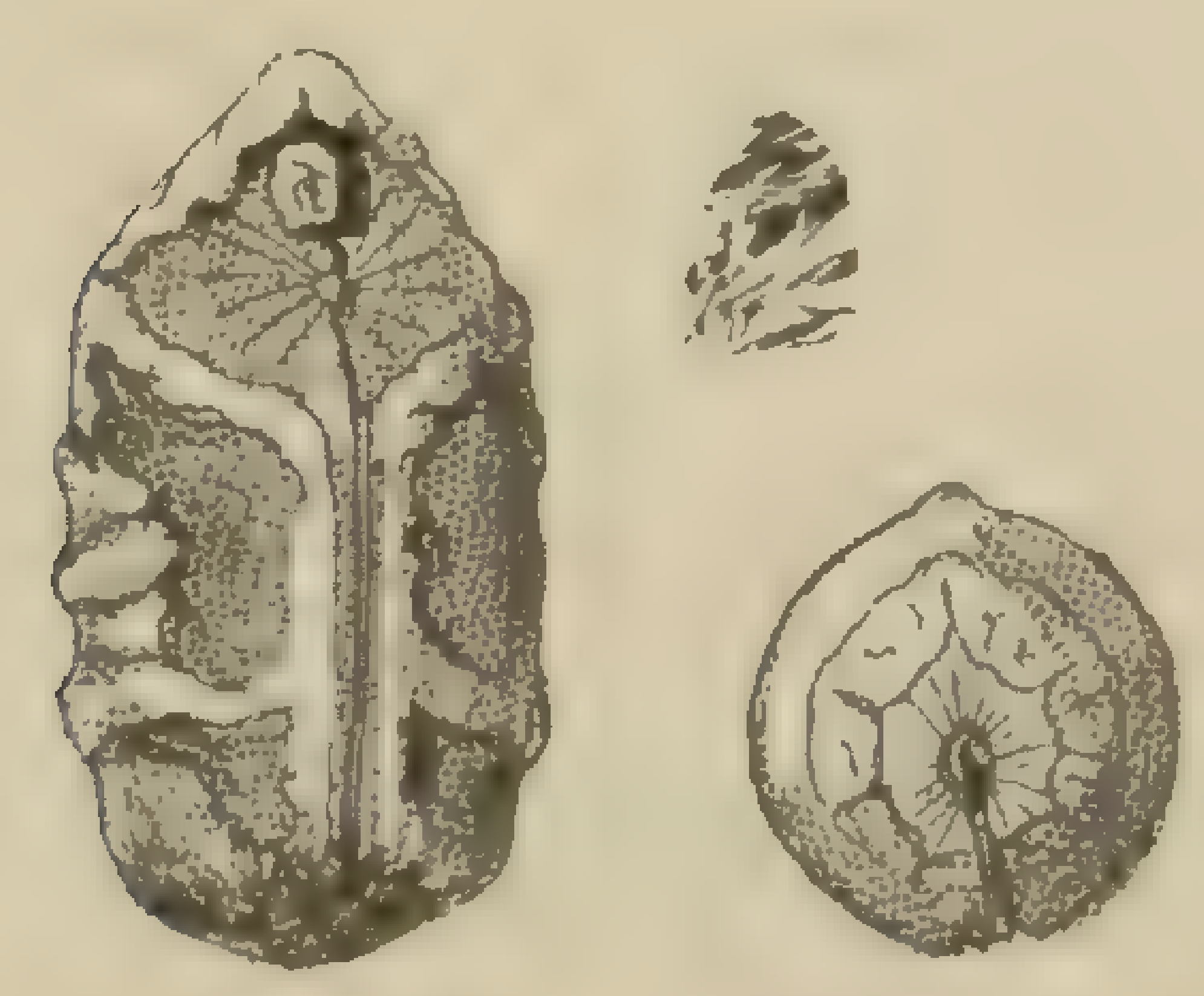
Euphorbia Jaliscensis **Durangensis** var. nov.

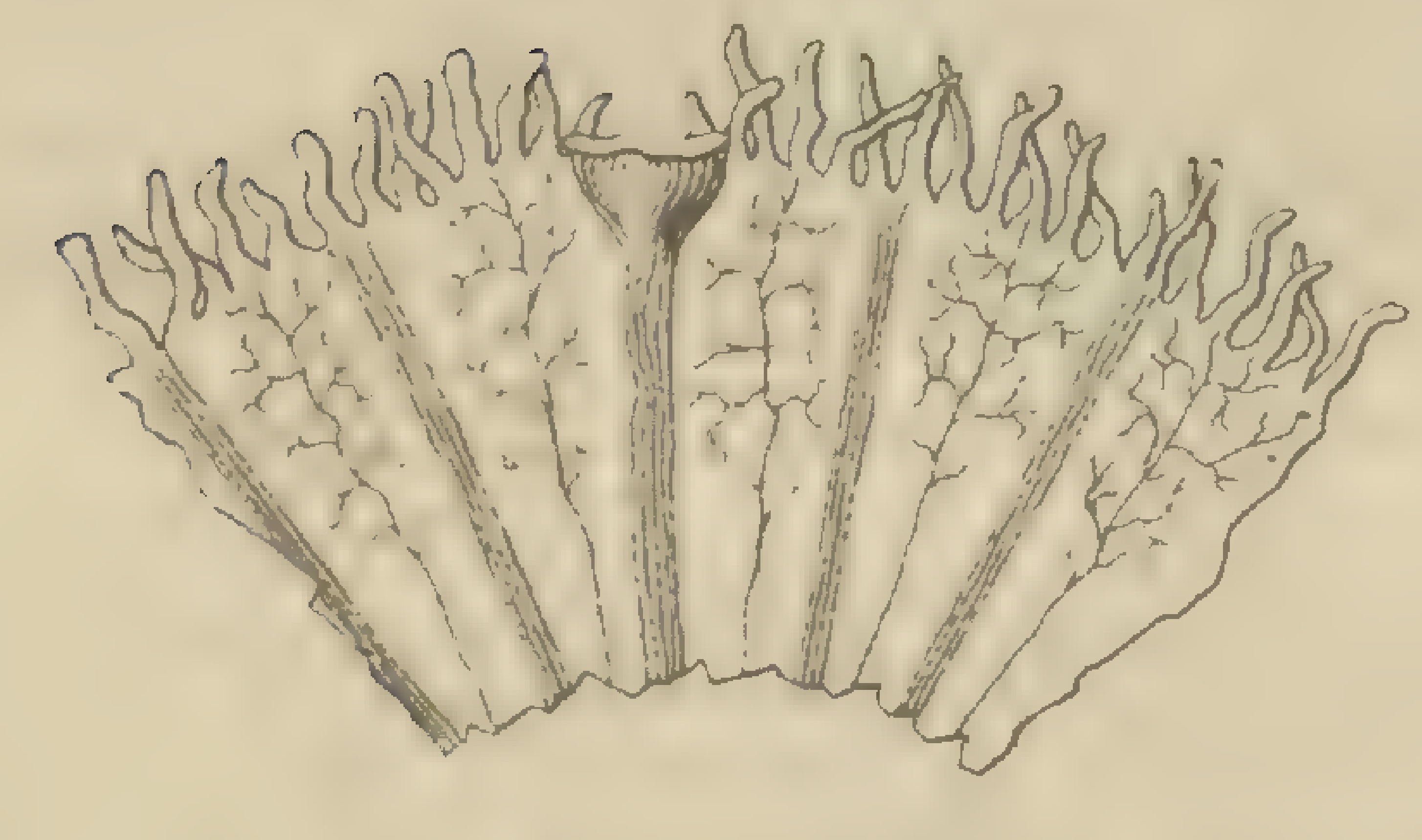
This form differs from the species in its denser foliage and more ramose habit. Heterophyllous; lower leaves linear-lanceolate, 0.5 to 4 inches long, upper leaves spatulate to panduriform, dentate at the cuneate apex, 1-2 inches long, as broad above the constriction as below. Involucre smaller than in the species, the glands less stipitate, the appendages narrower and only 4–6-crenate-dentate, the seed blacker and smaller (3^{mm} long, 1.8^{mm} broad), and the caruncle simply peltate.

Collected by Dr. Edward Palmer in the vicinity of Durango, 1896 (658).

Euphorbia radians Benth. Pl. Hartweg. 8.







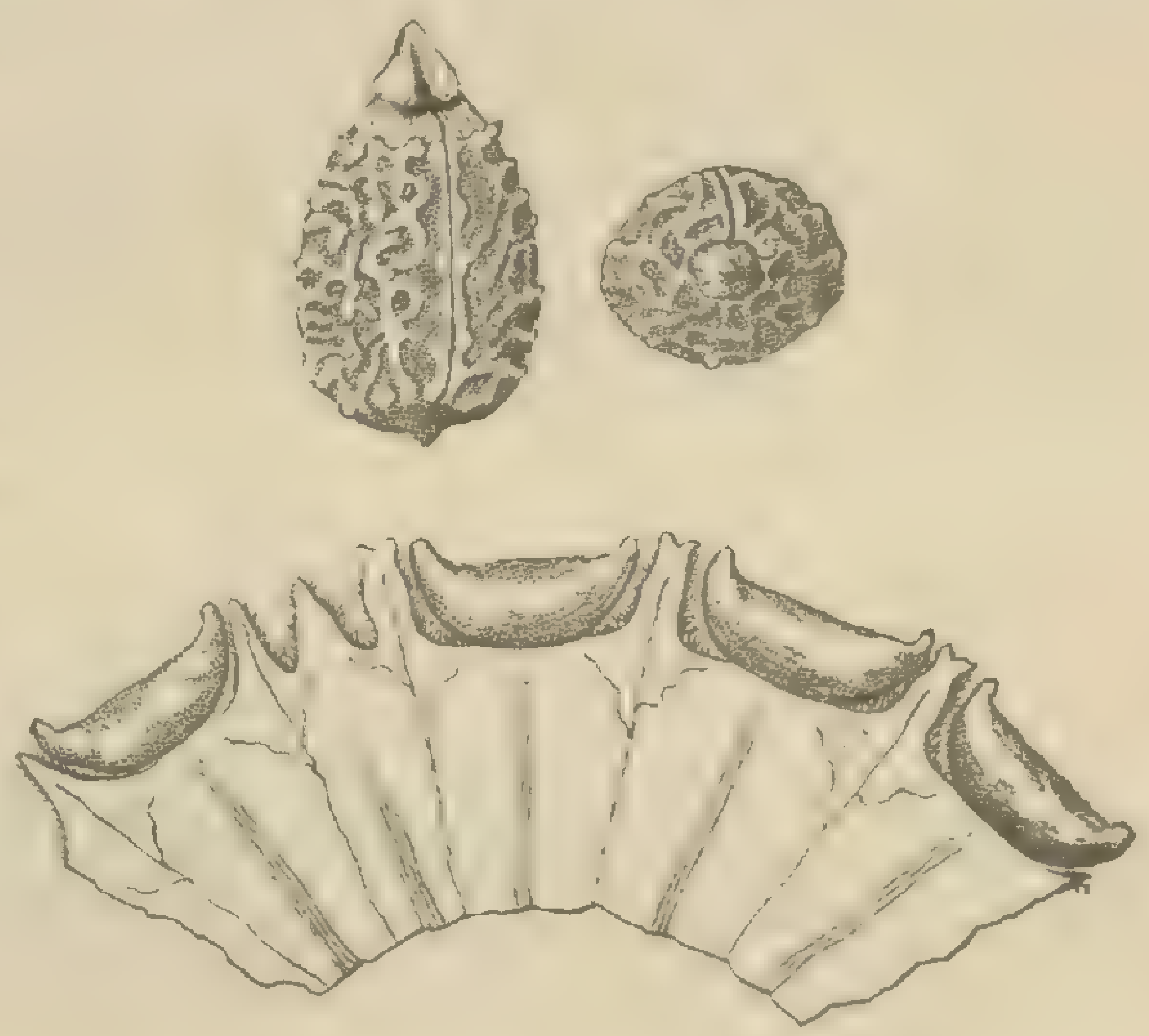
The involucres of this species, described by Boissier (DC. Prod. **15**: 74) as subsessile, are pediceled one-half the length of the tube; the involucral lobes are from 4–6-fimbriate, the four missing glands are replaced by similar 1–2-fimbriate false lobes. The seeds are ashen, ovate, globular in section, 4.1^{mm} long, by 2.5^{mm} broad, the ventral facets marked by a strong transverse ridge, the dorsal by two, and numerous irregular verrucæ, not "smooth;" a smooth seeded species could hardly belong to Poinsettia.

In Dr. Palmer's 34 Durango, the strigose hairy leaves are very characteristic, and agree with J. G. Lemmon's Huachuca mountains and C. Mohr's Gila river (Arizona) forms.

§ TITHYMALUS.

EUPHORBIA CAMPESTRIS Cham. & Schl. Linn. **84**: 1830.

In this species the fifth gland is replaced by a triangular pointed lobe, broader at the base than the involucral lobes, which are in part triangular and part fusiform with a bifurcate apex. The seed is oval, lenticular in section, 2^{mm} long, 1.3^{mm} broad, dark brown, the surface reticulate with rounded anastomosing whitened-farinose ridges. Caruncle conical stipitate, deeply notched on the ventral surface.



Dr. Palmer's 72 Durango is the typical form of the species, with long virgate branches denuded below and terminated by numerous narrowly-lanceolate mucronate-tipped leaves, and a single 3–5 flowered umbel.

FIELD COLUMBIAN MUSEUM,
Chicago.

A GENERAL REVIEW OF THE PRINCIPAL RESULTS OF SWEDISH RESEARCH INTO GRAIN RUST.[1]

PROFESSOR DR. JAKOB ERIKSSON.

SINCE 1890 extensive researches into grain rust have been carried on at the Experiment Station of the Royal Swedish College of Agriculture. The results of these researches from the years 1890 to 1893 will be found in an extended official report,[2] and from the years 1894 to 1896 in a series of smaller papers in different journals.[3] The general review of the principal results of these investigations, which I am about to give, can best be set forth in some general theses that comprehend the sum of the results obtained.

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[1] Lecture before the second Scandinavian Congress of Agriculture at Stockholm, July 20, 1897.

[2] J. ERIKSSON and E. HENNING. Die Getreideroste, ihre Geschichte und Natur, so wie Massregeln gegen dieselben. Stockholm: P. A. Norstedt & Sön, 1896, 8vo (2; VII+463+1).

[3] J. ERIKSSON, Über die Specialisierung des Parasitismus bei den Getreiderostpilzen (Ber. d. deutsch. bot. Ges., 1894, 292–331); Über die Förderung der Pilzsporenkeimung durch Kälte (Centralbl. f. Bakter. u. Paras.-Kunde, 1895, Abt. 2, 557–565); Ist die verschiedene Widerstandsfähigkeit der Weizensorten gegen Rost konstant oder nicht? (Zeitschr. f. Pfl.-Krankh., 1895, 198–200); Welche Grasarten können die Berberitze mit Rost anstecken? (*Ib.*, 1896, 193–197); Welche Rostarten zerstören die australischen Weizenernten? (*Ib.*, 1896, 141–144); Neue Untersuchungen über die Specialisierung, Verbreitung und Herkunft des Schwarzrostes (Jahrb. f. wiss. Bot., 1896, 377–394); Studien über den Hexenbesenrost der Berberitze (Puccinia Arrhenateri Kleb.) (Cohn's Beitr. z. Biol. d. Pfl., 1897, 1–16); Vie latente et plasmatique de certaines Uredinées (Compt. rend., 1897, 475–477); Der heutige Stand der Getreiderostfrage (Ber. d. Deutsch. Bot. Ges., 1897, 183–194); Einige Bemerkungen über das Mycelium des Hexenbesenrostpilzes der Berberitze (*Ib.*, 1897, 228–231); Zur Charakteristik des Weizenbraunrostes (Centralbl. f. Bakt. u. Paras.-Kunde, 1897, Abt. 2, 245–251); Neue Beobachtungen über die Natur und das Vorkommen des Kronenrostes (*Ib.*, 291–308); Schutzmassregeln gegen die Berberitze (Zeitsch. f. Pfl.-Krankh., 1897, 65); Über den Berberitzenstrauch als Träger und Verbreiter von Getreiderost (Die landw. Vers.-Stat., 1897, 83–95) und Weitere Beobachtungen über die Specialisierung des Getreideschwarzrostes (Zeitsch. f. Pfl.-Krankh., 1897, 198–202).

1. *The kinds of fungus which produce rust in cereals are at least ten in number (partly species, partly specialized forms of species), and the spread of the disease from one kind of cereal or grass to another is thereby considerably restricted.*

In order to illustrate the situation of the grain rusts in this regard, I would call attention to the accompanying table, in which can be seen what the former situation was, that is to say, in 1890 when this investigation began, and what it is now in the summer of 1897.

At the first glance this table shows how different the position is now from what it was formerly. Then we supposed that three species of rust were found on our cereals; one of them called *Puccinia graminis* occurred on all the four cereals, another *P. rubigo-vera* (*P. straminis*) on rye and wheat, and a third *P. coronata* on oats, to which finally a fourth form, *P. simplex* on barley, was added, ordinarily considered to be only a variety of *P. rubigo-vera.* We also thought that all the kinds of Gramineæ that bore a certain species of rust (*P. graminis* is observed on a hundred species of Gramineæ in Sweden) were able to infect one another.

How different our apprehension must now be! It appears that if we stop with the four cereals we have to count in Sweden not less than ten different forms of rust, and I have cause to suspect that on the continent of Europe one or two other forms are to be found. These ten forms are distributed among at least five species in such a way that there occurs

(1) One form of black rust on rye and barley,
(2) One form of black rust on oats,
(3) One form of black rust on wheat,
(4) One form of yellow rust on wheat,
(5) One form of yellow rust on barley,
(6) One form of yellow rust on rye,
(7) One form of brown rust on rye,
(8) One form of brown rust on wheat,
(9) One form of dwarf rust on barley, and
(10) One form of crown rust on oats.

SYSTEMATIC TABLE OF THE FORMS OF THE GRAIN RUST FUNGUS, PUCCINIA.

Formerly: (1880): Species Variety.	1 GRAMINIS Pers. (Aecidium Berberidis)		2 RUBIGO-VERA DC. (Aec. asperifolii)			3 CORONATA Corda (Aec. Rhamni)		
					SIMPLEX Kcke.			
Now (1897): Species:	1 GRAMINIS Pers.[4] Black rust (Aec. Berberidis)	2 PHLEI-PRATENSIS Er. & Hen. Timothy rust (Aec. –)	3 GLUMARUM (Schw) Er. & Hen. Yellow rust (Aec. –)	4 DISPERSA Er. & Hen. Brown rust (Aec. Anchusae)	5 SIMPLEX (Kcke.) Er. & Hen. Dwarf rust (Aec. –)	6 CORONIFERA Kleb. Crown rust (Aec. catharticae)	7 CORONATA (Corda) Kleb. (Aec. Frangulae)	8
Specialized forms:	1 SECALIS on *Secale cereale* " *Hordeum vulgare* " " *jubatum* " *Triticum repens* " " *caninum* " " *desertorum* " *Elymus arenarius* " *Bromus secalinus* 2 AVENAE on *Avena sativa* " " *elatior* " " *sterilis* " *Dactylis glomerata* " *Alopecurus pratensis* " *Milium effusum* " *Lamarckia aurea* " *Trisetum distichophyllum* 3 TRITICI on *Triticum vulgare* 4 AIRAE on *Aira caespitosa* 5 AGROSTIDIS on *Agrostis canina* " " *stolonifera* " " *vulgaris* 6 POAE on *Poa compressa* " " *caesia*	on *Phleum pratense* " *Festuca elatior*	1 TRITICI on *Triticum vulgare* 2 SECALIS on *Secale cereale* 3 HORDEI on *Hordeum vulgare* 4 ELYMI on *Elymus arenarius* 5 AGROPYRI on *Triticum repens*	1 SECALIS on *Secale cereale* 2 TRITICI on *Triticum vulgare* 3 AGROPYRI on *Triticum repens* 4 BROMI on *Bromus arvensis* " *Bromus brizaeformis*	on *Hordeum vulgare*	1 AVENAE on *Avena sativa* 2 ALOPECURI on *Alopecurus pratensis* " *Alopecurus nigricans* 3 FESTUCAE on *Festuca elatior* 4 LOLII on *Lolium perenne* 5 GLYCERIAE on *Glyceria aquatica* 6 HOLCI on *Holcus lanatus* " *Holcus mollis*	1 CALAMAGROSTIS on *Calamagrostis arundinacea* " *Calamagrostis lanceolata* 2 PHALARIDIS on *Phalaris arundinacea* 3 AGROSTIS on *Agrostis vulgaris* " *Agrostis stolonifera* 4 AGROPYRI on *Triticum repens* 5 HOLCI on *Holcus lanatus* " *Holcus mollis*	1 EPIGAEI on *Calamagrostis epigeios* 2 MELICÆ on *Melica nutans*

Between certain of these forms, that is to say, those which constitute a species (for instance the three forms of black rust) we have not succeeded in discovering, even with the aid of a microscope, any distinguishing difference in the outer appearance, such as the size, color, and distribution of the pustules, the shape and size of the spores, etc. However, there is a difference between them with regard to their inner nature that is of no little practical interest. The difference appears in that every form is almost exclusively confined to its particular cereal, and that consequently it is able to infect no cereal but that one. Thus stems of oats bearing black rust can propagate black rust to oats, but not to rye, wheat, or barley; stems of rye bearing crown rust can propagate crown rust to rye, but not to wheat, and so on. Plants of rye and barley attacked by black rust make an exception to this rule, as they are able to infect one another; in some cases also those of wheat propagate black rust to other cereals.

If we consider the thirty-seven kinds of grasses mentioned in the table, we observe that the forms of rust upon them distinguished at the present time reach the number of thirty, and that these forms are brought together under seven species.

The old *P. graminis* has been divided into two species, that is to say, *P. graminis* (black rust) with æcidium, and *P. Phlei-pratensis* (timothy rust) without æcidium; *P. rubigo-vera*, its form *simplex* included, has been divided into three species, *P. glumarum* (yellow rust), *P. dispersa* (brown rust), and *P. simplex* (dwarf rust); and finally *P. coronata* into two species, *P. coronifera* (crown rust) with æcidium on *Rhamnus cathartica*, and *P. coronata* with æcidium on *R. Frangula*. Two forms, the last two in the table, are for the present arranged separately because we have

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[4] In this column are yet to be arranged the forms of black rust on the following nine grasses: *Aira flexuosa*, *Alopecurus nigricans*, *Elymus glaucifolius*, *Panicum miliaceum*, *Phleum Boehmeri*, *P. Michelii*, *Poa chaixii*, *P. pratensis*, and *Triticum unicum*, with regard to their capacity for passing to a barberry. So far it has not been possible, on account of lack of æcidiospores, to range each of these forms in its proper place in the species.

not yet been able to effect any tests by which their true place can be defined.

We can easily see that the consequence of this abundance of forms ought to be a very considerable reduction in the capacity of the rust to propagate itself from one species of grass to another. To be sure rye and barley are able to infect one another with black rust, as illustrated in the table, and they also can be infected by *Triticum repens*, *T. caninum*, and several other grasses. In the same manner oats may be infected with black rust from *Dactylis glomerata*, *Alopecurus pratensis*, and several other grasses. For all the other eight forms of rust occurring on our cereals, however, as well as for the forms of rust on the wild grasses and the fodder grasses generally, it has not been possible to discover any source of the disease among surrounding grasses of other species.

But some one may ask if the proofs brought forward for the difference between the forms—proofs which have been gathered from experiments with the fungi in their uredo stage, as they occur on culms and leaves of grasses—are completely satisfactory. If it is a fact, as seems to follow from the table, that all forms of black rust are like each other in that they are able to alternate on barberry, producing an æcidium upon it, of course the query presents itself whether this bush is not able to serve as a connecting bridge between the forms which show their distinguishing features in the uredo stage; whether, indeed, an æcidium that, for instance, arises from the black rust on oats may not be able to produce an outbreak of black rust not only on oats, but also on the other cereals, nay, on every grass that is susceptible to black rust. Many trials made during the last six years have proved conclusively, however, that it is not so. An æcidium arising from black rust on oats is able to infect, among the cereals, only oats, while an æcidium arising from black rust on rye or barley can produce rust only on rye or barley, and so on. The different forms of black rust are thus entirely separated one from another in all their stages—as uredo and puccinia on the grasses and as æcidium on barberry

—and the small propagation of black rust by external infection, mentioned above, is not at all affected by the intervention of the barberry.

2. *The propagation of rust is often slight* (a) *between species of Gramineæ capable of bearing the same specialized form,* (b) *to and from the æcidium host* (*where there is one*), *and sometimes* (c) *between different cultivated varieties of the same cereal.*

By reference to the table we observe that the form of black rust first mentioned, called *f. sp. secalis*, may occur on rye and barley, as well as on *Triticum repens*, and several other grasses. In middle and southern Sweden *T. repens* is more often and abundantly attacked by black rust than any other grass. It would be natural to suppose that if the several Gramineæ named grew in the vicinity of one another and one should be attacked the infection would ordinarly spread to the others. If so, rye and barley ought to be frequently attacked by black rust. Such, however, is not the case. Barley is comparatively little affected by this form of rust, and rye does not suffer from it to any great degree.

It has been observed, furthermore, that barley growing near *Triticum repens* covered with black rust has remained clean week after week, although the weather had been very favorable for the propagation of the disease. We may incidentally allude to other observations in which the propagation of the disease from rusted stalks to the æcidium host, or contrarily from this plant to susceptible Gramineæ has been much less than we expected.

But, also, propagation of rust has very often appeared to be small between different cultivated forms of the same kind of cereal, and even between different individuals of the same grass. There is, indeed, scarcely an agriculturist who has not sometimes observed that different varieties of wheat are very differently attacked by yellow rust. One variety may be almost clean, while another is entirely destroyed. Such a case which was particularly noted may be here related. In the summer of 1894 a variety of winter wheat (Horsford's pearl wheat), very susceptible to yellow rust, was cultivated at the Experiment Station in a small plat. Round this plat five other varieties of wheat were sown, also in small plats, all these varieties being well known for several years as very little susceptible to yellow rust. On May 11 the middle plat showed traces of yellow rust. After thirty-three days the rust had increased a little, and after ten days more the rust had reached its maximum, the greatest degree of destruction. But at the same time all the surrounding plats at the end of the thirty-three days were clean, and at the end of the following ten days two plats still continued quite clean, and the other three only showed small traces of rust. All the plats were sown on the same day, and the weather during the last part of May and the beginning of June was part of the time very rainy.

Here we have an example of what is usually called the different susceptibility of varieties to disease. Such a different predisposition for yellow rust we have up to this time been able to point out with certainty in different varieties of wheat and barley. In view of observations made during the summer of 1896, I have reason also to suspect such a predisposition in the different varieties of wheat for brown rust, a kind of rust, however, that has but subordinate practical interest in Sweden.

Sometimes we find only a slight propagation of rust, even between different individuals of the same wild grass. I have observed specimens of *Festuca elatior* badly attacked by *Puccinia coronifera* alternating with healthy ones, or specimens of *Poa pratensis* destroyed by *P. Poarum* alternating with healthy ones, or specimens of *Brachypodium silvaticum* attacked by *P. Baryi* among completely healthy ones.

3. *The germinating power of the uredo- and æcidiospores is often small, or at best capricious.*

The fact that the yellow rust in wheat shows so little transmission from one variety of wheat to another has led to making the germination of summer spores (uredo- and æcidiospores) the subject of special investigation. It appears that in certain kinds of rust these spores are uniformly very capricious in their germination, and even sometimes absolutely refuse to germinate.

even if they lie in water for four or five days. Such is the case for instance with the uredospores of yellow rust (*Uredo glumarum*), with æcidiospores of black rust (*Æcidium Berberidis*), and so on.

The cause of this remarkable state of things has been a matter of much perplexity, and many experiments were set on foot in order to learn a way of increasing the germinating power, at least to some extent. Such a way was finally discovered, which was to cool them. Ever since the old Roman days cultivators have observed that alternating cool nights and warm days favor the development of rust. From this the thought came to me to cool the spores by putting them on ice, or by chilling them in water for several hours. How strange it is, indeed, that these experiments should often give positive results! The dormant power of germination is brought to life, and with certain kinds of spores only in this manner has it been possible to carry out infection experiments. This capricious germination partly accounts for the small propagation of the disease already mentioned. But this alone does not give complete explanation, for such a restricted propagation is also to be observed in forms whose spores as a rule germinate very well. The whole cause must, therefore, be sought elsewhere.

4. *The spread of rust depends to an important degree upon the distances.*

For the purpose of explaining the outbreak and spread of rust in grain fields we have not generally been concerned with the distances separating the fields from a suggested source of infection. The pustules of rust once appearing on the barberry, the primary source of the whole neighborhood's infection was thought to have been found. It was believed that at first the nearest fields became rusted, through them in eight days afterwards the somewhat remote region, and so on. The farther from the original source, the more secure one could be. Sometimes, however, this protective distance must apparently be considerable. Black rust has been observed in the Indian wheat fields with no barberry as the source of infection nearer than 300 miles, on the Himalayas. However, we sometimes find recorded a different opinion. Thus, one of the most respected authorities in this subject, Professor Julius Kühn, of Halle, proclaimed the opinion in an official report of 1875 that a distance of 100 meters between the barberry bush and the grain field may be considered sufficiently protective.

During the last few years many experiments have been set on foot at the Experiment Station, and many observations made in the open field, in order to gain some knowledge regarding this important question, and all these experiments and observations point to the same conclusion. They show that the matter of distance is of the greatest importance, as well in the spread of the disease in spring from rusted Gramineæ to barberry, etc., as in a like spread in summer from barberry, etc., to the Gramineæ, and finally from one of the Gramineæ to another. This has been found true not only for a single year, but for all the years, at least five, that I have had my attention turned to the subject. By observation on the rust's appearance upon *Triticum repens* at different distances from a barberry bush it has been proved beyond doubt that the influence of the bush does not extend farther than 10 to 25 meters.

For these reasons it was insisted upon in the circular, which a short time since was sent out to several of the officials in Sweden, that no barberry, wild or cultivated, be permitted to grow at a distance less than 25 to 50 meters from a grain field.

5. *The germinating power of the winter spores* (*teleutospores*) *depends upon certain external conditions, and is restricted to a short period of time.*

The winter spores of black rust are capable of germination in spring only in case they have been exposed to quite natural conditions of cold, snow and rain, during the previous winter; and consequently rusted litter preserved in a barn or in a stack is not to be regarded as dangerous. This has been fully demonstrated in the results of the first four years as given in the detailed report.

Observations and experiments made during the current year have brought to light still another matter of interest concerning the germinating power of the spores. It appears that only the crop of spores maturing during late autumn is able to germinate the following spring.[5]

All that I have now set forth — (1) the multiplicity of fungous forms producing the rust disease, (2) the obstinacy of some uredo- and æcidiospores in germination, (3) the great importance of the matter of distance, and (4) the conditional and short-lived germinating power of the teleutospores — cannot well be brought into agreement with the view which has been held, and is yet generally prevalent, with regard to the outbreak and propagation of grain rust, and we may perhaps say of parasitic plant diseases in general, viz., that it is the continual accession of new infective material and the continual formation of new centers of infection which cause the outbreak and the intensity of the disease. The five theses set forth above give each in its degree a hard wrench to the corner stone upon which the whole doctrine of grain rust has been resting for a long time.

It may be asked whether this overthrow of prevailing opinions is the only or principal result of the investigations. Does it not present some more positive result, some new starting-point upon which a new doctrine may be founded, and from which new work may begin? I am obliged to be brief at this time, and to give merely a short and summary review of my results, referring for details to the special works already published or soon to be published.

I shall first call attention to two observations that were easily made, but no less remarkable for that reason. Each of them gave cause to suspect a source of rust quite different from that which we have been accustomed to look for.

6. *The yellow rust appears in certain varieties of wheat and barley that are especially susceptible, uniformly four to five weeks after sowing.*

7. *The intensity has sometimes been stronger in sunny than in shady places in the same wheat field.*

These two observations, together with the results from several special investigations upon the succession of the rust pustules, etc., related in the work "Die Getreideroste," could not fail to excite suspicion that perhaps the source of disease is an internal one, included within the plant itself.

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[5] Details will soon be published elsewhere.

How then test whether this suspicion might be right or not? The first experiments made with this in view showed that

8. *Wheat plants, which early in the spring, immediately after the melting of the snow, were enclosed in long and large glass tubes stuffed with cotton wool above and below, and consequently carefully protected against external infection, developed stalks that after six to eight weeks showed yellow rust.*

There is no possibility of explaining this outbreak of rust through external infection taking place immediately before or after enclosing in the tubes. The immediate sources of the disease in these cases must have been an internal one. Here two possibilities seem to suggest themselves. The first is that in late autumn of the previous year, during early growth of the wheat, an external infection came from teleutospores or uredospores of the yellow rust, germinating upon the seedlings; and that the fungus afterwards lived a hidden internal life until the full outbreak in the spring. The other possibility is that germs of disease had been inherited by the seed grain from the parent plant itself.

In order to decide between these two possibilities it has been necessary to arrange the experiments in a special way. Therefore I have sowed grain in sterilized soil and protected the growing plants from external infections by raising them in glass houses constructed so that the air could pass in only through cotton-wool filters. Such experiments in glass houses of different construction have been carried on for four years, and have shown that

9. *Plants of a variety of barley extremely susceptible to yellow rust, grown in sterilized soil and protected from external infection in isolated glass houses, have sometimes become rusted.*

These results prove beyond doubt that the disease must come from internal germs inherited from the parent plant.

But in what form are these internal germs of disease living? Is it easy to follow and identify them with the microscope? Not at all. They can only be detected just before the breaking out of the young pustules. The microscope examination induces me to suppose that

10. *The fungus lives for a long time a latent symbiotic life as a mycoplasma in the cells of the embryo and of the resulting plant, and that only a short time before the eruption of the pustules, when outer conditions are favorable, it develops into a visible state, assuming the form of a mycelium.*

To speak comprehensively, the investigation above outlined gives the following general conclusions:

A. The outbreak of grain rust is due (a) *in the first place to germs of disease in the host plant itself, which in certain cases are inherited from the parent plant through the seed, and in which they lead a latent symbiotic life as a mycoplasma and continue to do so afterwards for a long time in the resulting plant, and* (b) *in the second place to external infection from the vicinity.*

B. The intensity of grain rust is due (a) *in the first place to the degree with which the dominant outer circumstances* (*weather, soil, manuring, and so forth*) *are able to convert the inner germs of disease from the latent stage of a mycoplasma into a visible stage of mycelium, and* (b) *in the second place to the accession of infective material from without.*

So far have we now gone in our knowledge of the nature of grain rust. Many things that before seemed incomprehensible have now a natural explanation, and our point of view has been very much changed. Especially have the experiments so far carried out provided a new method for explaining the varying susceptibility of different varieties of cereals, and have thus given a new point of departure for continued efforts for the mastery of the disease in the open field. We are warranted in suggesting that the predisposition of the Hosford wheat to yellow rust may be explained by assuming that between this variety of wheat and the yellow rust an extremely vital mycoplasma-symbiosis is to be found, while on the contrary the Squarehead wheat is nearly exempt from the rust for the reason that no such symbiosis has arisen between this wheat and the fungus.

With this fundamental view as a point of departure we have yet to ascertain to what degree we can by different manures, by different treatment of the soil, by different time of sowing, etc., influence the internal germs of disease in such a manner that the transformation from the latent mycoplasma stage to the sporiferous mycelium stage may be as much as possible delayed and prevented. We have further to make use of the knowledge gained in the selection and cultivation of varieties as little susceptible to the disease as possible. We have to find out to what degree by crossing we can combine a small susceptibility to rust with a strong resistance to cold, and finally whether certain regions may not tend to repress the development of the inner germ of the disease, and thus become regions for the production of certain kinds of cereals.

The questions above mentioned are of great practical importance, and they suggest a very rich field for further investigations

STOCKHOLM, SWEDEN.

RED YEASTS.

KATHERINE E. GOLDEN and CARLETON G. FERRIS.

(WITH PLATES II AND III)

THE so-called red yeasts are what are known as "wild" yeasts, and occur usually in the air. Though several species of these yeasts are known, but two, *S. rosaceus* and *S. glutinis*, are described and named. *S. rosaceus* has been studied by Hansen, but as no spores were formed during its development, he excluded it from the true Saccharomycetes. The same exclusion should apply to *S. glutinis*, for in this species, also, spore formation is unknown. In an article of recent publication, Swan[1] describes a red yeast obtained from a stale egg, which formed spores, although under somewhat extraordinary circumstances. Instead of forming spores on the gypsum block or on filter paper in the ordinary way and at 25° C. or 15° C., Swan obtained the spores in growths on wort gelatine, in the light, and at a temperature between 5° 10° C., the first indications of spores appearing in ten to fourteen days. He does not state whether or not he used ordinary conditions before resorting to these somewhat peculiar ones. The article is accompanied by photographs which show unmistakable spore formation in the yeast cells.

Of three red yeasts which the writers obtained from the air of the laboratory, and designated numbers 1, 2, 3, number 1 was at first supposed to be the same form that Swan had examined, but with subsequent work it proved to be different, varying in certain characteristics, notably the manner of growth of the colonies and the spore formation. The colonies show considerable growth in three days, and are of a dull pink color. They are not raised from the surface of the gelatine as were those of Swan, but are round and flat and have smooth edges (*Plate II*,

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[1] Central. f. Bakt. u. Parasitenk. **2**: 1–11. 1896.

A). As the colonies age their color becomes much deeper, until in old growths the color is a vivid red. The color is not affected by the ordinary acids or alkalies. The cells show no color under the microscope, are oval or round, the average size being 8.6 μ × 6.4 μ. During vigorous growth the cells have from one to three vacuoles, the protoplasm shows very little granulation, and no chain formation takes place. The cells form but one bud at a time, and the bud separates from the mother cell before a second bud is formed. The following table gives the characteristics of growth under various conditions:

NUMBER 1.

No.	Kind	Medium	Temp.	Color	Manner of growth	Age days
1	Streak	10% Wort-gelatine	21° C.	Red	Abundant, oily in appearance, smooth edges	21
2	"	"	7° C.	Pale pink	Slight growth, oily, smooth edges	21
3	"	"	17° C.	Red	Same as no. 1	21
4	Stab	"	21° C.	Red	Growth on surface only, oily, smooth edges	21
5	"	"	7° C.	Pale pink	Slight growth, other respects like no. 4	21
6	"	Agar	21° C.	Deep red	Growth very heavy	21
7	"	Starch paste	21° C.	Pale pink	Slight growth on surface.	14
8		Wort	21° C.	Pink	Heavy sediment, liquid turbid, no gas, ring at surface	4
9		Bouillon	21° C.	Pale pink	Slight sediment, liquid cl'r, thin granular film	4
10		5% Dextrose	21° C.	Red	Heavy sediment, liquid cl'r, no gas	18
11		"	7° C.	Faint pink	Slight growth	47
12		Glucose	21° C.	Pink	Like no. 10, but less sediment	18
13		"	7° C.	Faint pink	Slight growth	47
14		Sucrose	21° C.	Red	Most abundant growth of sugar solutions, liquid slightly turbid, thin film, heavy ring at surface	18
15		Dist. water	21 C.	Very faint pink	Slight sediment, cells empty	11
16		Lactose	21° C.	Pink	Next to 14 in growth, film	18
17	Ferm. tube	Pasteur sol. with sugar	21 C.	Pink	Sediment in bend of tube, no gas	30

The foregoing table gives a general idea of the conditions used for the growth of number 1. It was found that the yeast in a stab culture in gelatine or agar gave no growth along the needle track, the color being entirely at the surface, this showing it to be aerobic. Upon 10 per cent. wort gelatine and nutrient agar the best growths were obtained, and in the light. Various temperatures were tested, that between 17°-21° C. being found the best. At one time twenty-four varieties of yeast were grown at that temperature, and of the twenty-four number 1 gave the most vigorous growth. The color shows sooner and is stronger when the growth is made in the light. Inoculations in beer wort give a very appreciable growth in two days, the liquid becoming turbid, and a sediment forming. No film is formed, but in about a week a thin ring appears around the surface of the liquid; this ring increases in size and deepens in color with the age of the culture. Fair growths, as indicated by the sediment, were obtained in bouillon and in distilled water; in the latter, however, little color was present. Cultures in sugar solutions—sucrose, dextrose, maltose, lactose, and Pasteur solution with sugar—were made, and all of them offer good media for growth, though varying considerably. Remarkably large growths were obtained in lactose and sucrose, these being characterized by heavy sediment of a deep red color, heavy surface ring, and turbid liquid. A peculiar phase of the growth in sucrose is that the cells formed spore-like bodies. In no other of the sugars did this occur. Cultures in the sugars and in wort were made in fermentation tubes, but no gas was formed, though the cultures were kept for two months.

Spore formation was tested in the usual way, vigorously growing cells being placed on gypsum blocks. The blocks were kept under various conditions of light and temperature, with the result that at from 17°–21° C., and in the dark, granulations appeared in cells, these afterward forming spore-like bodies. The granulations first appeared in about forty hours, though it was about four days before the spore-like bodies were formed. These bodies are round and highly refractive, averaging 3.3μ in size, but developed no spore wall that could be distinguished. Being doubtful as to the true nature of these bodies, and thinking that probably they might be fat globules, the cells were treated with ether, alcohol, osmic acid, potash, and alkanet, all of which failed to change the bodies. Some of the cells were then placed in a drop of wort in a moist chamber at 25° C. to determine their method of germination. The chamber was placed under the microscope, so that any changes might be observed. In sixteen hours the bodies had become swollen, and they passed gradually from the swollen condition to the ordinary condition of the protoplasm in a vegetative cell. The spore-like bodies formed in the sediment and film of a 5 per cent. sucrose solution were tested in the same way, with like results. The conclusion which can be drawn from the behavior of this organism is that it is not a true yeast, but that the cells have the power of forming bodies which function as spores in preserving the organism from extinction under adverse conditions.

Plate III, B, shows the cells from a gypsum block with the contained bodies. Growths on blocks kept in the dark and at 7° C. developed but slight color, while blocks kept at 21° C. developed quite a marked color, both in the dark and in the light, thus indicating that a certain amount of heat is necessary for color development.

NUMBER 2.

No.	Kind	Medium	Temp.	Color	Manner of growth	Age days
1	Streak	Wort-gelatine	21 C.	Salmon pink	Oily, smooth edges, abundant	20
2	"	Agar	"	"	Oily, smooth edges, more abundant than in no. 1	20
3	Stab	Wort-gelatine	"	"	Slight growth along needle track	20
4	"	Agar	"	"	Slight growth along needle track	20
5	"	Starch	"	"	Oily growth on surface	20
6	Ferm. tube	Pasteur sol. with sugar	"	Pink	Sediment in bed, no gas	30
7		Bouillon	"	Pale pink	Heavy sediment, liquid turbid	18
8		Dextrose	"	"	Heavy sedim't, liquid clear	20
9		Lactose	"	"	" " " "	20
10		Glucose	"	"	" " " "	20
11		Sucrose	"	"	" " " "	20

The colonies of no. 2 are somewhat indistinct in color until they are about ten days old, when they have a yellowish-red color. Their general appearance is very nearly the same as those of no. 1, but when magnified, differences show, as seen in *Pl. II, C*. The plate cultures of the three forms, from which the photographs were taken, were made at the same time and under similar conditions. The photographs were also taken at the same time. The cells of no. 2 are round, averaging 4 × 4μ in size, and bud frequently. In stab cultures a slight growth appears along the needle track. In streak cultures, as also in colonies and the top of stab cultures, the growth is very oily in appearance, and possesses little or no color at first, though this develops as the culture ages, until in very old ones the color is quite marked. As in no. 1, the color is unaffected by the ordinary acids and alkalies. In wort and sugar solutions the growth is fairly vigorous, though not so much so as in no. 1. No film is formed, nor is any gas developed. No spores or spore-like bodies are formed either on gypsum blocks or in any of the growths, the only change in the cells, when placed under conditions for spore formation, being a granulation of the protoplasm.

NUMBER 3.

No.	Kind	Medium	Temp.	Color	Manner of growth	Age days
1	Stab	Agar	21° C.	Faint pink	Slight growth along needle track, surface growth dry, granular, abundant	14
2	Stab	Gelatine	"	Pink	Like no. 1	14
3	Streak	Agar	"	Pink	Growth abundant, dry, floury, most of color in center in heaviest growth, edges almost white	20
4	Streak	Gelatine	"	Pink	Like no. 3	20
5	Stab	Starch	"	Faint pink	Slight growth on surface	14
6		Wort	"	Pink	Turbid after a week, granular film, sediment heavy, no gas	20
7		Lactose	"	Faint pink	Slight sediment, no film, no gas	14
8		Dextrose	"	"	" " " "	14
9		Glucose	"	"	" " " "	14
10		Sucrose	"	"	" " " "	14

In no. 3 the colonies are entirely distinct from those of nos. 1 and 2; they stand out from the gelatine as feathery masses with very irregular edges, and of a salmon pink color. *Pl. II, D* shows the peculiar appearance very well. At first sight the colonies look somewhat like a mold, but upon closer inspection they show no ramifying filaments. This peculiar appearance of the colonies is due to the form of the cells, and their remarkable method of growth. A few of the cells have the regular round or oval shape of the ordinary yeast cell, but the remainder have irregular, swollen, or filamentous forms, resembling the involution forms of bacteria. *Pl. III, E* is from a vigorous growth on gelatine. These forms, with about the same length of filament are constant for young growths on solid media, also for the first colonies obtained from exposure to the air. In old growths the form varies, the filaments becoming much longer, and more branched; this lengthening and branching also takes place in cells grown in liquid media. *Pl. III, F* is a photograph from an old growth. *Pl. III, G* is a photograph from a culture in wort. The cells, though branching in a manner which resembles a mold, never develop a mycelium. The cells vary in size from 1.5μ to 3.13μ for the short diameter, and 3μ to 29μ for the long diameter. A fairly vigorous growth is obtained at room temperature on agar and wort gelatine. On both of these the growth is dry and floury in appearance, of a light pink color, and in stab cultures most of the growth is on the surface, only a slight growth appearing along the needle track. In wort it takes four or five days usually before there is sufficient growth to make the liquid turbid; then a film, that is granular, appears on the surface. There is no fermentation in wort or in any of the sugar solutions. In starch paste there is a slight pinkish growth on the surface, but very slight, however, compared with the growth on gelatine and agar.

Of the three forms studied not one of them is a true Saccharomyces. They resemble the Saccharomycetes in their appearance, both microscopically, and in gross growth, but they are unable to form true ascospores. No. 1 appears to be a form between the Saccharomycetes and the Torulae, in that it forms spore-like bodies under the ordinary conditions for spore formation, but these bodies are not true spores, as they neither form the spore wall, nor bud in germinating. It resembles *S. rosaceus*, as heretofore described—excluding Swan's description—in appearance of colonies, and in not forming chains, but differs from it in forming spore-like bodies, and in size; *S. rosaceus* is 9-10μ in diameter, a larger form than no. 1. No such form is described in any of the standard works upon the Saccharomycetes, which would indicate that it is a new species.

No. 2 is undoubtedly *S. glutinis*, in spite of the fact that it is not of the same size as the *S. glutinis* as described in some of the later works. No. 2 answers the description in every other particular. An error seems to have crept into the description of this species in regard to its size, the other characters being practically the same in all the descriptions. Cohn[2] in 1875 gives 4–5μ as the size, while Winter[3] in 1881 gives it as 5-11 × 4μ, Schröter,[4] in 1893, gives 5–6 × 4–5μ, and Saccardo,[5] in 1897, gives the same size as Winter, 5–11 × 4μ. Jelliffe[6] in a list of Saccharomycetes occurring in the air gives *S. glutinis* among the number, but as he gives no description of his forms, it is impossible to tell which description he followed. The following description,[7] which was written by Schröter indicates probably the source of the error: *S. glutinis* (Fres.) F. Cohn (Zellen kugelig, 4–5μ breit) und *S. Fresenii* Schröter (Zellen ellipsoidisch bis cylindrisch, bis 11μ lang, 4–5μ breit) schlagen sich häufig aus der Luft auf Leim nieder und bilden fleisch-bis rosenrote Schleimhäufchen.

No. 3 from its peculiar appearance would seem to be easy of identification. In general appearance it is very like *Mycoderma Humuli* as described by Lasché,[8] but it is unlike in that *M. Hum-*

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[2] Beiträge zur Biologie der Pflanzen **1**: 187-8. 1875.

[3] Krytogamen-Flora von Deutschland **1**: 71. 1881.

[4] Krytogamen-Flora von Schlesien **3**: 207. 1893.

[5] Sylloge Fungorum **8**: 919. 1897.

[6] Bull. Torr. Bot. Club **24**: 480-1. 1897.

[7] Engler and Prantl, Pflanzenfamilien **1**^{1}: 154. 1894.

[8] Zwei rothe Mycoderma-Arten. Der Braumeister **5**: 278-82. 1892.

uli liquefies the gelatine very quickly, sinking to the bottom as a red mass, forms a ring at the surface, and decomposes the liquefied gelatin, generating a foul odor, whereas no. 3 neither liquefies gelatin quickly nor gives off a foul odor in any stage of its culture. The indications are that no. 3 is a new species of Mycoderma.

Thanks are due to Dr. J. C. Arthur and Dr. Stanley Coulter for assistance rendered in the preparation of this paper.

PURDUE UNIVERSITY, Lafayette, Ind.

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EXPLANATION OF PLATES II AND III.

PLATE II.

A. Colonies of no. 1 grown on 10% wort gelatine. ×100.

C. Colonies of no. 2 grown on 10% wort gelatine. ×100.

D. Colonies of no. 3 grown on 10% wort gelatine. ×100.

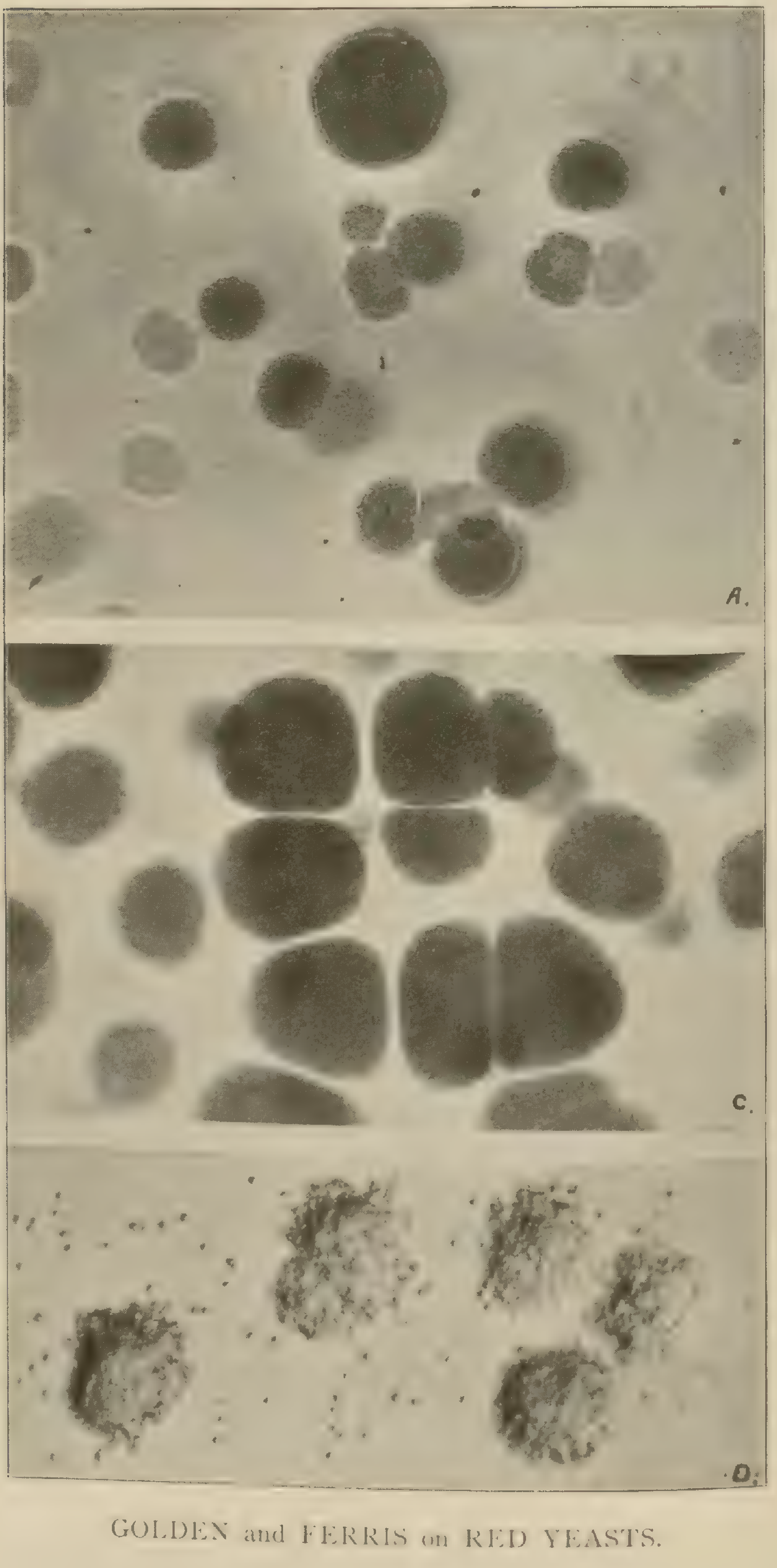
PLATE III.

B. Spore-like bodies, no. 1, grown on gypsum plates. ×495.

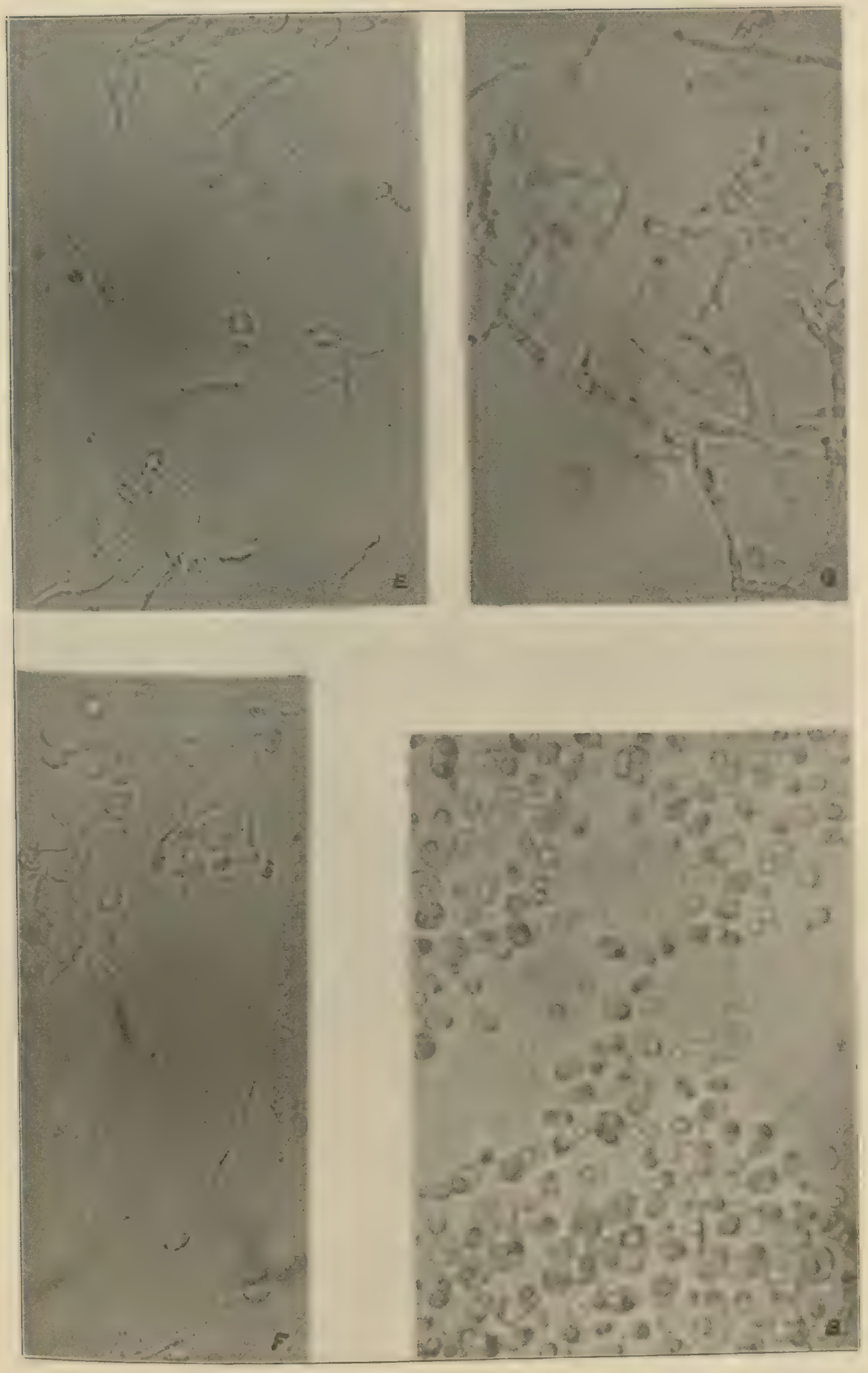
E. Cells of no. 3 grown on 10% wort gelatine. ×495.

F. Cells of no. 3 from old growth on agar. ×495.

G. Cells of no. 3 grown in wort. ×495.



GOLDEN and FERRIS on RED YEASTS.



GOLDEN and FERRIS on RED YEASTS.

BRIEFER ARTICLES.

CYNODON OR CAPRIOLA?

A BIBLIOGRAPHICAL STUDY.

WHILE engaged in a study of the Glumifloræ, as treated by the earliest botanical writers, we met not infrequently with the name "Capriola," which seemed to have been intended for some grass with digitate inflorescence. This name having been restored by Adanson as the earliest one for the genus now generally known as Cynodon, we felt induced to investigate the matter. Furthermore, Capriola has been revived by Dr. Otto Kuntze, and upon his authority it has been introduced into American systematic works of recent date, wherein the species appears as *Capriola Dactylon* Kuntze. It seems, however, as if the restoration of this name furnishes a good illustration of the difficulty sometimes confronting the naturalist who strives to determine what generic name ought to be adopted as the correct one for a certain plant, and since we have not been able to ascertain the true identity of the grass which formerly bore the name Capriola, we have thought that the present bibliographical sketch might be of some interest to American botanists. It is true that Adanson [1] restored the name, thinking it was identical with *Gramen dactylon* of the ancient writers, and his diagnosis, although very incomplete, does point toward Cynodon, which he thought was the plant which the ancient writers had in mind when they spoke of Capriola. Nevertheless, it is a very difficult matter to define Capriola as a definite genus, and at the bottom of the difficulty lies the fact that there are several other grasses with digitate inflorescence which were well known even to the earliest writers. It is quite natural that such grasses, unlike as they are to the majority of grasses, should attract attention at an early date, but it is also evident that the old botanists could not draw any clear distinction between the genera of such grasses, but simply referred to them as "finger-grasses." Some of these have later been recognized as *Panicum sanguinale*, Cynodon, Chloris, Dactyloctenium, Eleusine, Paspalum, etc.

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[1] For references consult the bibliography appended to the article.

The fact is that Capriola was intended for *Panicum sanguinale* or for Cynodon, or perhaps for both together, but in no instance has this name been applied to any plant which can be identified with absolute certainty as the Bermuda grass, the genus Cynodon of Richard in Persoon's *Synopsis*. It is to be noted furthermore that Capriola is constantly preceded or followed by another name "Sanguinaria," sometimes written "Sanguinella," and it seems very significant that this last name is to be recognized as a modern popular one for *Panicum sanguinale*, viz., Paspale sanguin, Blutt-grasz, and Blut-hirse. But Capriola is not preserved in any form and gives no clue to its identification. It is derived from *caper*, not as a diminutive, but simply as indicating a plant liked by goats. The occurrence of Cynodon in sandy sections of the old world, where goats are kept in large numbers, may well speak for Cynodon as the grass it was made for, especially since *Panicum sanguinale* does not thrive well in sandy soil, but prefers the uncultivated grounds near dwellings, vineyards, etc. The popular name of Cynodon is, as we remember, Chien-dent, Hahnenbein, finger-grass, Bermuda-grass, etc.

We might add, in order to explain the singular popular name of our *Panicum sanguinale*, that this grass was once known to possess "bloody" properties. Thus both Dioscorides and Pliny have described a grass: "cui in cacumine caulinum quini sunt aculei veluti digiti," about which they state that when the spikes were pressed into the nostrils a bleeding was produced, and yet this same grass was used in dressing wounds to stop bleeding. This grass was generally known, therefore, as "Sanguinella" by the Etruscans, while others called it Capriola. It is interesting to notice that while the former use of Sanguinella has evidently been abandoned, the latter was recommended by Loeselius as late as the beginning of the eighteenth century. This author attributes this effect to his so-called Blutt-grasz, which according to his description must have been *Panicum sanguinale*. Whether Capriola, Sanguinaria, or Sanguinella were really intended as names for one single plant, it is unquestioned that the two latter have left a deeper trace in the history of economic plants than has Capriola. Such statements as are given by Dioscorides and Pliny concerning the medicinal properties of plants are of the greatest use in ascertaining the generic or specific name of some plant whose description is left too obscure. It seems, therefore, that by merely considering the name and properties of the plant in question, we might be justified in supposing that *Panicum sanguinale* was the Sanguinella of the ancient writers. As regards Capriola, this name was generally used in connection with the former, as a local name for a plant, which at that time was considered identical with Sanguinella or Sanguinaria. However, there is a third name, "Dactylon," which was used by Pliny for a "finger-grass" possessing the same properties as Sanguinella, but there is no further clue to its identity. This plant "Dactylon" has evidently formed the basis for a number of finger-grasses by later writers, enumerated as *Gramen dactyloides*, etc., and it was one of these which Adanson considered as identical with Capriola. We see from these early data how very uncertain Capriola stands as a genus in botanical history, and we shall herein try to demonstrate that a consultation of the writers in the sixteenth and seventeenth centuries does not show any closer identity of Capriola with Cynodon.

Leonard Fuchs was perhaps the first writer who tried to identify Sanguinaria and Capriola, of which he makes mention in a chapter, "De Manna," in Brunfels' *Herbarum vivae eicones*. Both names are referred by Fuchs to the so-called "manna grass." Very few Gramineæ are described by Ruellius, but he knew Pliny's *Gramen aculeatum*, which he has discussed briefly. He mentions a new name for this grass, *Dens canis*, from which the later French name, "Chien dent" became derived ; but he refers also to Capriola and Sanguinaria as synonyms. There is only one point in his very brief description of this grass which seems to throw some light upon its identity, and this is that the number of spikes is given as "quini senive." Cynodon is not known to produce more than four or five branches in the inflorescence, while it is very common to find seven in *Panicum sanguinale*. Although Lobelius has described a *Gramen Canarium* recognizable as Cynodon, and an *Ischæmon vulgare* which may be our Panicum, he does not give any reference to either Capriola or Sanguinaria. In accordance with Fuchs the "manna-grass" was adopted by Dodoens, who has not only described but even figured two species, *Gramen Manna primum* and *alterum*, both of which may readily be identified as *Panicum sanguinale* and *P. Crus-galli*. The figure of the first is so well executed that it makes any further comment unnecessary. We find here for the first time a true representation of *P. sanguinale*, and its geographical distribution was at that time given as Germany, Bohemia, Italy, and Belgium, where it was cultivated, but was found also naturalized in uncultivated fields, etc. One of its popular names

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1900.

was at that time "Ros coeli" or "Himmel-dau," perhaps taken from its ability to retain the dew. This is the grass, Dodoens says, which Leonicenus and Ruellius have identified as the one formerly known as Capriola or Sanguinaria. Only three years after Dodoens we find Sanguinella and Capriola as synonyms for *Gramen Mannæ* in the writings of Camerarius, followed by the very important statement that this grass, whose figure bears great resemblance to *Panicum sanguinale* but not to Cynodon, was eaten by the Germans.

There exists no record heretofore that the grains of Cynodon have ever been gathered for eating, inasmuch as this grass yields but a relatively small number of mature seeds, a fact that is perhaps due to its extensive propagation by stolons. No mention is made in the elaborate works of Clusius of either Capriola or Sanguinaria. He merely describes *Gramen legitimum* and *Ischaemon*, in which our two plants seem to have been badly confounded. In accordance with Camerarius, Dalechamps describes "Grame de Manna," the figure of which is very characteristic, and shows us *Panicum sanguinale* without any question. He enumerates as synonyms Capriola and Sanguinella, and states that this plant is cultivated in south Europe. He has also described and figured Cynodon, which he calls "Dent de chien," but does not with one word allude to its possible identity with the former. This is perhaps the earliest record of a popular French name for Cynodon, which in later years became transcribed into "Chien-dent." The manna-grass has thus begun to be more generally adopted for our Panicum, and becomes also used in England, where Gerarde takes it up as his "*Gramen Manna esculentum*, the dew-grass," the last of which was evidently derived from Dodoens' "Ros coeli." A second species is Gerarde's "*Ischaemon vulgare*, the cock's-foot grasse," which is figured and seems to represent *Panicum glabrum*, while in his *Gramen dactyloides radice repente* we are able to recognize Cynodon. Following Gerarde, Parkinson has also adopted "cock's-foot grasse" for Panicum, whose Latin name he gives as *Ischaemon sylvestre*, while he calls Cynodon *Gramen Canarium Ischaemi paniculis*. A singular confusion as regards the name is to be observed in Johannes Bauhin's *Historia plantarum*, where *Panicum sanguinale* is figured, but named *Graminis genus Dens caninus*. Bauhin states in a small paragraph, however, that he does not believe that the identity of this grass with Capriola and Sanguinaria, as quoted from the ancient writers, can be ascertained without question. These grasses were distinguished, nevertheless, by the younger Bauhin, who named them "*Gramen dactylon folio latiore*" (Panicum), and "*Gr. dactylon fol. arundinaceo*" (Cynodon).

By bringing all these statements together, drawn up from the various writers as far back as we have been able to trace our Panicum and Cynodon, it does not appear that Capriola was ever intended for Cynodon alone, but rather for *Panicum sanguinale.* The constant quotation of Capriola and Sanguinaria together seems to indicate that these were merely synonyms and popular names used in Italy. There are only two instances where we have found these names used for plants outside of the Gramineæ, but this is of little importance. Dodoens also used "Sanguinaria" for a plant which is readily recognized as *Polygonum aviculare;* and Tabernæmontanus in the beginning of the seventeenth century enumerated both Capriola and Sanguinaria as species of his genus Coronopus, which are easily identified as *Plantago Coronopus* and *maritima.* All the other writers have agreed that both Capriola and Sanguinaria are grasses, and Adanson is correct in applying Capriola to a grass. But this author does not seem to have had any reason for assigning the name *Gramen dactylon*, this name being yet too obscure.

If in spite of its uncertainty Adanson's name Capriola is to stand for the mere sake of priority, the question remains whether it is really identical with Cynodon or with *Panicum sanguinale.* The diagnosis given by Adanson for Capriola is not so characteristic that one can recognize in this the genus Cynodon of Richard. "Couronne de la gaîne des feuilles: poils; fleurs: épis digités; calice: plat par les côtés; corolle; sans arête," are characters that may just as well fit *Panicum sanguinale.* We have examined numerous specimens of this last and noticed that the ligule is often wanting and replaced by a small tuft of hairs, while the same organ in Cynodon is sometimes developed as a crescent shaped membrane. Furthermore, the empty glumes are also laterally compressed in *Panicum sanguinale*, and no awn is developed. Indeed, it seems as if Capriola has become more obscure through having been restored by Adanson than it was before. The adopting of Capriola must consequently result in confusion, which would easily be avoided by preserving Richard's well defined genus Cynodon, which no botanist could ever mistake for *Panicum sanguinale.* The fact that *Gramen dactylon* is a very obscure name, that Capriola of the old writers has been used for Panicum or for this and Cynodon together, and that Adanson's restored genus is not so certain, does not encourage us to adopt Capriola for the mere sake of priority or for any other reason. It seems to be much more practical to use Richard's name, which is not antedated by any similar name, and which is well known to all botanists.—THEO. HOLM, *Washington, D. C.*

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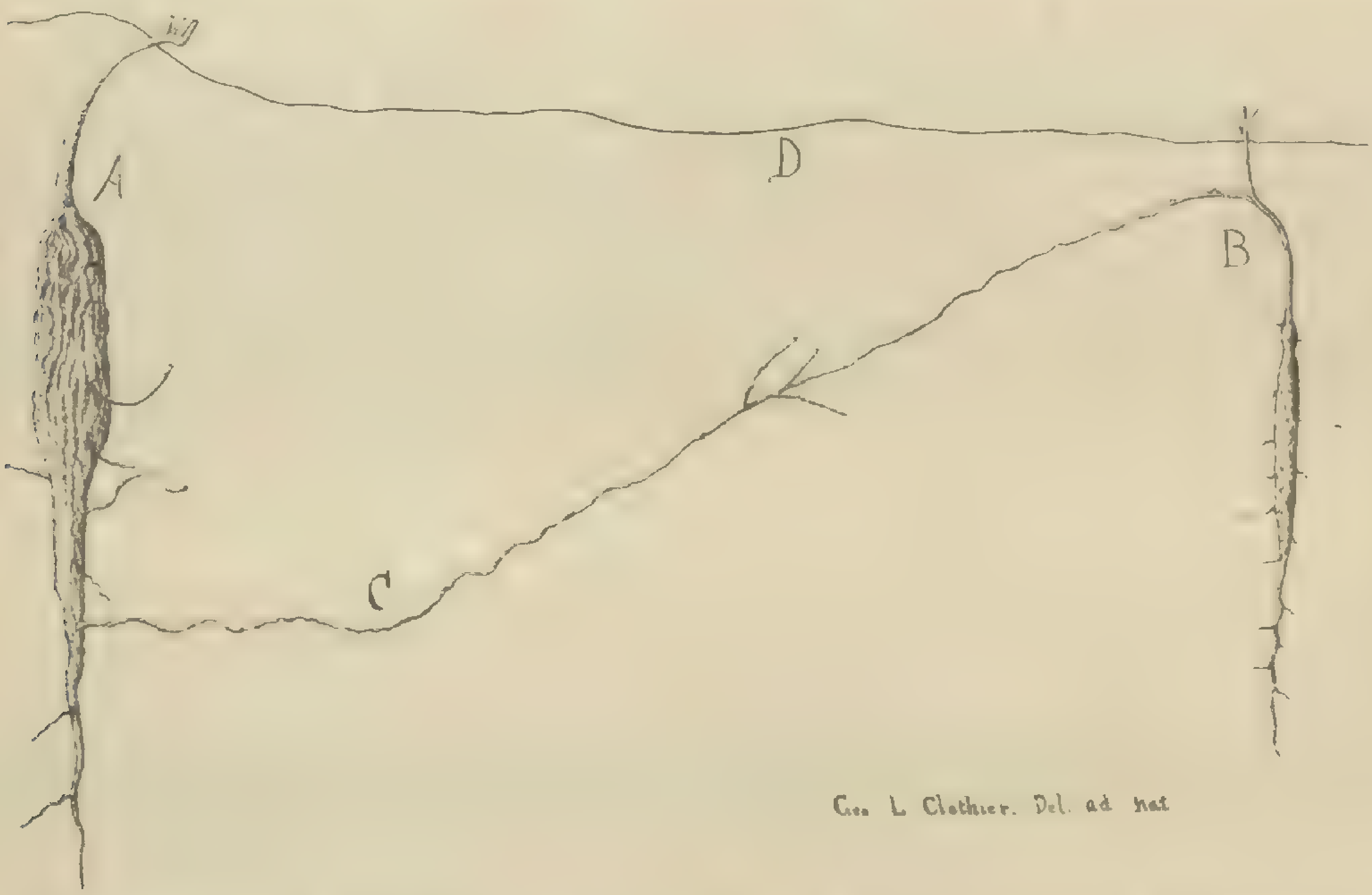
ROOT PROPAGATION OF IPOMŒA LEPTOPHYLLA.

A FEW notes upon the root propagation of *Ipomœa leptophylla* Torr. may be of interest, as the facts herein presented are believed to be unpublished.

As is well known, this plant, whose habitat is the dry sandy regions of the plains, has a fleshy, spindle shaped tap root that often attains an enormous size. In adult plants, the surface of this is covered with a corrugated woody layer that hinders evaporation, while the inner tissue is stored with abundant food materials.

The propagation roots originate from various parts, more abundantly from the lower part of the vertical fleshy root, pass out horizontally for a short distance, then rise to near the surface of the ground several feet away from the mother plant, where adventitious buds are produced. A number of young plants may have their origin in series from a single propagating root. The buds are formed only where the root has attained to the proper distance from the surface of the ground for the thrifty growth of the young plants. Each young plant, while still connected with its parent, sends down a fusiform fleshy root which penetrates the soil to a depth of three or four feet.



Root propagation of *Ipomœa leptophylla* Torr. *A*, parent plant ; *B*, young plant ; *C*, propagating root ; *D*, ground line. Reduced to $\frac{1}{19}$ natural size.

The accompanying figure shows the fleshy root of an old plant connected with a young plant by one of its propagating roots. This plant had six other horizontal roots that were presumably propagation roots also. It was noticed that the propagating root under consideration was thinnest at a point two or three feet away from the young plant, and that it branched back of this point, probably giving rise to propagating rootlets of other young plants. It took its origin from the mother plant about three feet below the surface of the ground.—GEORGE L. CLOTHIER, *State Agricultural College, Manhattan, Kansas.*

NOTES ON LILÆOPSIS.

MR. J. B. S. NORTON, of the Missouri Botanical Garden has just called our attention to the fact that *figs. 3* and *4* were transposed in our revision of this genus.[2] *Fig. 3* is the fruit of *L. Schaffneriana*, and *fig. 4* that of *L. Carolinensis*, as the descriptions indicate.

Mr. Norton sends a specimen of our new species *L. Carolinensis* from New Orleans, collected by J. F. Joor. The only locality known to us was eastern North Carolina.

The eastern distribution of *L. lineata* is usually given as from Massachusetts to Mississippi, but we have never seen specimens west of Florida.

Collectors along the Gulf coast should endeavor to discover whether these two species are found there, and learn definitely their distribution. The flowers of Lilæopsis are always given as being white, but in *L. Carolinensis* Dr. Joor says they are pink.—JOHN M. COULTER and J. N. ROSE.

THE PHYSIOLOGICAL PROBLEMS OF TODAY.[3]

IF it be true that the fundamental problem of physics is the constitution of matter, it is equally true that the fundamental problem of physiology is the constitution of living matter. I think the time has come for physiology to return to its fundamental problem.

Living matter is a collective term for the quality common to all living organisms. Comparative physiology alone enables us to discriminate between the general properties of living matter and the functions of specific organs, such as the blood, the nerves, the sense organs, chlorophyll, etc. Nothing has retarded the progress of physiology and pathology more than the neglect of comparative physiology. Comparative physiology shows that secretion is a general function of all living organisms and occurs even where there is no circulation. Hence it was *a priori* false and a waste of time to attempt to explain secretion from the experiments on blood pressure. Oxidations occur regardless of circulation and it was *a priori* a waste of time to consider the blood as the seat of oxidation. Comparative physiology has shown that the reactions of animals to light are identical with the heliotropic phenomena in plants. Hence it is a mistake to ascribe such reactions as the flying of the moth into the flame to specific functions of the brain and the eyes. Sleep is a phenomenon which occurs in insects and plants, and it would be a waste of time to attempt an explanation of sleep on the basis of phenomena of circulation. The best interests of physiology and pathology demand that the systematic development of comparative physiology be one of the physiological problems of today.

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[2] BOT. GAZ., 24: 48, 49. 1897.

[3] Delivered at the Ithaca meeting of the American Society of Naturalists, December 29, 1897. Dr. Loeb's paper is one of seven upon "The biological problems of today," each speaker being limited to ten minutes.

May I be pardoned for calling attention to one special field of comparative physiology which I believe to be especially fertile. I refer to the field of physiological morphology. I applied this name to the investigation of the connection between the chemical changes and the process of organization in living matter. Two series of facts allow us to connect these two groups of phenomena: (1) the fact that phenomena of fermentation lead to an increase in the number of molecules and thus bring about an increase of osmotic pressure in the cells, this increase of osmotic pressure being the source of energy for the work of growth: (2) the facts of heteromorphosis, *i. e.*, the possibility of transforming in certain animals one organ into another or substituting one organ for another through external influences, such as gravitation, contact, light etc.

The exact and definite determination of life phenomena which are common to plants and animals is only one side of the physiological problem of today. The other side is the construction of a mental picture of the constitution of living matter from these general qualities. In this portion of our work we need the aid of physical chemistry and especially of three of its theories; stereochemistry, van 't Hoff's theory of osmotic pressures, and the theory of the dissociation of electrolytes. We know that the peculiar phenomena of oxidation in living matter are determined by fermentative processes, and we venture to say that fermentations form the basis of all life phenomena. It has been demonstrated that fermentability is a function of the geometrical configuration of the molecule. *Saccharomyces Cerevisiæ* is a ferment for such sugars only as have three or a mutiple of three atoms of carbon in the molecule. Among the hexaldoses only δ-glucose, δ-mannose, and δ-galactose are fermentable, while their stereoisomers are not fermentable. But the influence of the geometrical configuration goes farther. Voit has suggested and Cramer has demonstrated that there is a far-reaching parallelism between the fermentability and assimilation of carbohydrates. Higher animals as well as yeast cells are able to form glycogen from such carbohydrates as are fermentable by yeast. The further development of these stereochemical relations and their extension to proteids and nucleins is another of the problems of physiology which will contribute to the main problem, the analysis of the constitution of living matter. I believe that the influence of stereochemistry will be more or less directly felt in many branches of physiology, in questions of heredity, as well as in the theory of space sensations as E. Mach has already intimated.

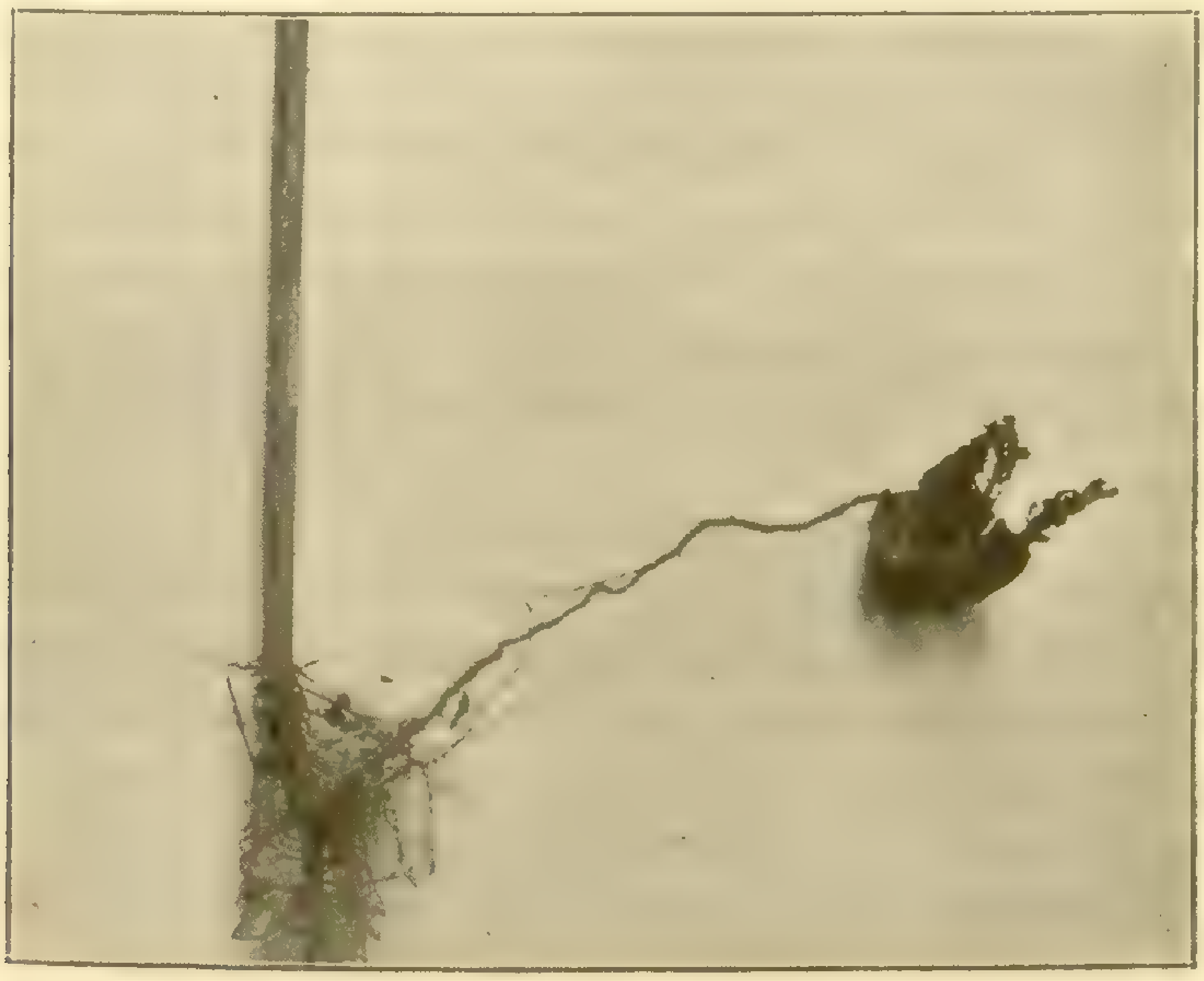
In living organisms chemical energy is frequently transformed into osmotic energy. Van 't Hoff's theory of osmotic pressure permits an application of the law of conservation of energy to a class of phenomena to which this law was hitherto inapplicable, namely the phenomena of growth, functional adaptation, secretion, absorption and even pathological processes such as œdema. The physiologists who thought that the blood pressure determined secretion could not understand why secretion took place under a higher pressure than the blood pressure. Comparative physiology shows that secretion does not depend upon circulation, and the theory of osmotic pressure indicates that the osmotic pressure in the cells is more than twenty times as high as the blood pressure. The work of secretion is done by osmotic pressure and not by blood pressure. A prominent physiological chemist has become a vitalist because he could not explain why the secretions differ from the blood from which he thinks they are formed. He overlooks among others the fact that the protoplasm possesses the quality of semi-permeability, which means that it allows certain substances to pass through and others not. In my opinion the working out of a theory of semi-permeability is one of the main physiological problems of the day.

The theory of the dissociation of electrolytes is of fundamental importance in the analysis of the constitution of living matter. Pharmacology will feel its influence most directly. Everything seems to indicate that the specific physiological effects of inorganic acids are due to the number of positively charged hydrogen ions in the unit of solution, and the specific physiological effects of alkalies to the negatively charged hydroxyl ions. But the universal bearing of the theory of dissociation upon physiology will perhaps be best seen in the field of animal electricity. An active element of living matter in a state of rest is negatively electric to its surrounding parts. We may assume that an acid is formed in the active part and that the passive parts are neutral. The positive hydrogen ions of the acid have a much greater velocity of migration than the anions. Hence the former will diffuse more rapidly into the passive tissue than the anions, and the active tissue will remain negatively charged.

At no time since the period immediately following the discovery of the law of conservation of energy has the outlook for the progress of physiology appeared brighter than at present. But in order to reap the full benefit of our opportunities we must bear in mind that the fundamental problem of physiology is the determination of the constitution of living matter, and that in order to accomplish our task we must make adequate use of comparative physiology as well as physical chemistry. Pathology, in particular, will be benefited by such a departure.—JACQUES LOEB, *The University of Chicago.*

APHYLLON LUDOVICIANUM ON AMBROSIA TRIFIDA.

I HAVE found the Louisiana naked broomrape to be one of the rare plants in this vicinity; but when found it has always been attached to



the roots of the great ragweed. The roots given out by the host, which connect the two plants, are at first small, so that it is almost impossible to trace them to their destination. But they steadily increase in size, until they are often as large as a wheat straw by the time the parasite has run its course, which is usually about the last of September. There is usually only one supply-root, and this is of nearly the same size its entire length, and a mat of small haustoria is developed by the guest at the point of contact. The parasitism appears to be complete, as the broomrape has no soil roots.

Perhaps the reason for the existence of some discrepancy and uncertainty as to the real host of some of the species of the broomrapes is due to the fact that they have not been kept under observation until the parasite had matured and withered.

The accompanying cut, made from a photograph and reduced to one-fourth natural size, shows in a striking manner how the one root of the ragweed has grown at the expense of the rest.—J. SCHNECK, *Mt. Carmel, Ill.*

BIDENS CONNATUS MÜHLENBERG.

IN THE year 1874 I found on lake Ruppin a form of Bidens, distinguishable at a glance from our two indigenous species (*B. tripartitus* and *B. cernuus*) by its basal bushy branching, the light green color of its almost always undivided stem-leaves narrowed into a short petiole. Upon closer observation I found that the involucral bracts of the flower-heads were mostly in fives, always non-ciliate, and longer than in *B. tripartitus*. Moreover the mature fruits always have four awns and the epidermis rather large warts (Höcker). These peculiarities led me to characterize this form (in *Verhandl. des bot. Ver. der Prov. Brandenburg* 1879: 157–158) under the name *B. tripartitus* L. var.? *fallax*.

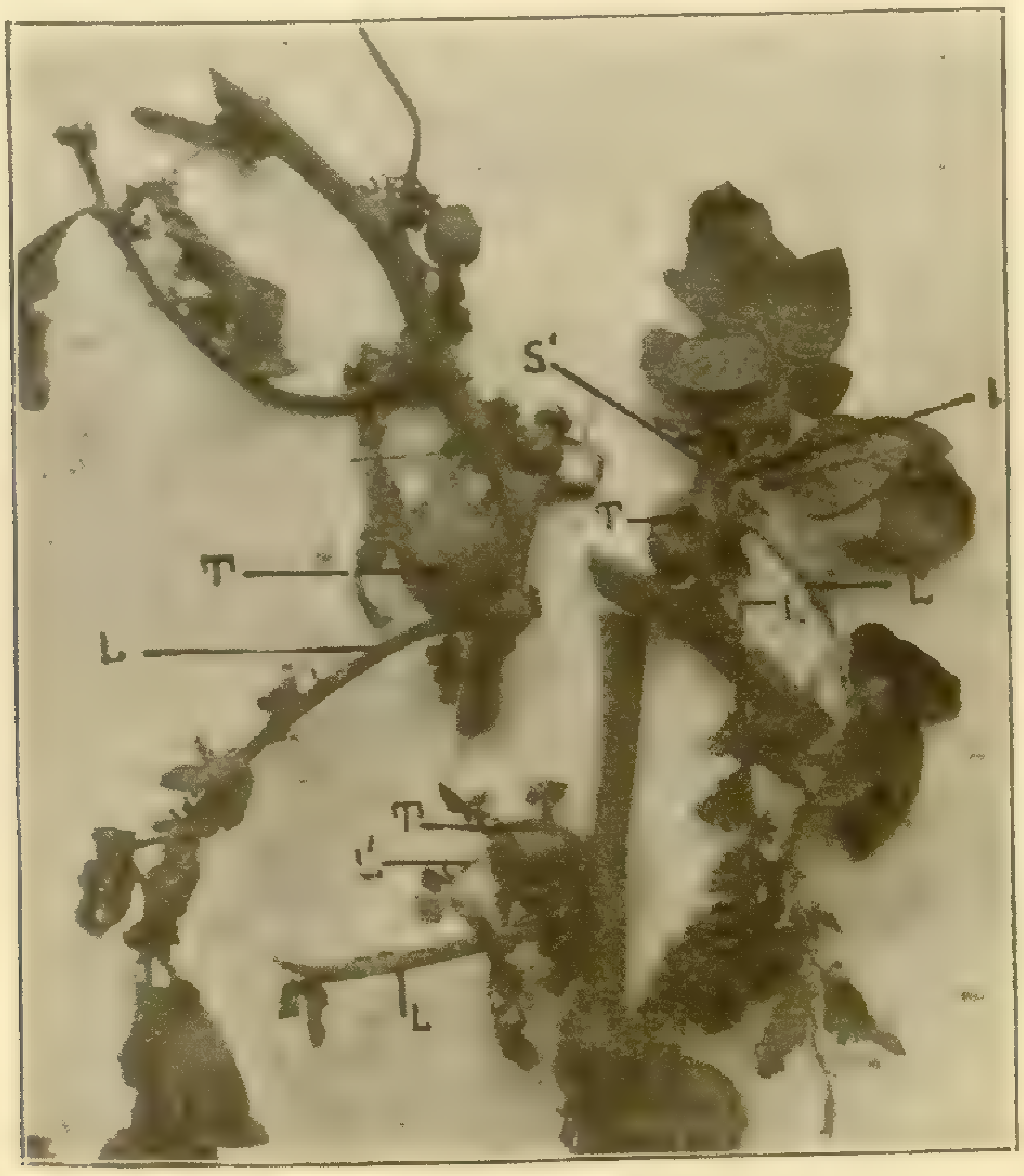
Since then, chiefly on account of my bryological studies, the plant has not come to my notice, until it turned up again in the autumn of 1895 on raft-logs in our lake. Of course I recalled having seen and remarked it many years before, but my especial notice of it in 1879 had entirely escaped my memory; thus it happened that after a thorough investigation, laying more stress upon the specific value of the warty four-awned fruit, I published it (in *Œsterr. bot. Zeitschrift* 45: 392. 1895) as *B. decipiens*.

Meanwhile, my long-time friend Professor Dr. Ascherson of Berlin, who had become interested in the plant, made an examination of the Berlin Botanical Museum and referred our plant, by Mühlenberg's type specimen, in Willdenow's herbarium under no. 15,021, to *B. connatus*. The matter would have been thereby settled had I not already received from various parts of North America as *B. connatus* an entirely different plant. In this the fruits are always smooth and usually two-awned, only occasionally having a shorter median awn. They are, thus, just like those of *B. tripartitus*. On this account the specimens from the United States heretofore seen by me cannot possibly be identified with Mühlenberg's type in the Willdenow herbarium, but belong to another good species.

It would be of great phytogeographic interest if the botanists of the United States would observe, now in their herbaria and next season in the field, whether *B. connatus* really occurs there with warty four-awned fruits, as in Europe, or whether this plant is there found only with smooth two to three-awned fruits. Perhaps there can be found in some of the older herbaria Mühlenberg's types, which might show whether the fruits are smooth or warty, two- or four-awned. In any case I should be greatly obliged for information on this point.—C. WARNSTORF, *Neuruppin, Germany*.

AERIAL TUBERS OF SOLANUM TUBEROSUM.

IN December 1895, some interesting specimens of aerial tubers were found on *Solanum tuberosum* in the garden of the steward of the Louisiana State University and Agricultural and Mechanical College, at Baton Rouge. My attention was called to them by Mr. Holmes.



the steward. The plant had no well developed underground tubers, but the stem above ground had developed on it upwards of fifty well formed tubers, varying in size from a half inch to two inches in diameter. Nor were they confined to the portion of the stem near the ground, but extended up the stem almost to the top. It is true the stem was not erect, but it was not more prostrate than others about it. The tubers were located in the axils of the normal leaves. In some instances there was only one tuber in the axil of the leaf, in others there were more, and in one case there were five. These tubers were of the shape and size of those ordinarily formed underground, but in many instances the leaf-scale of the normal potato was here developed into a large foliage leaf, which did not differ from the normal leaf of the stem. The tubers contained a large amount of chlorophyll, but were not as green as the stem. In most cases where leaves were developed on the tubers the bud in the axil of the leaf did not differ from the "eye" of the underground potato. In one or two instances, however, a branch was developed which, in turn, had three or four leaves. The cut shows one of these stems with its leaves, *L* marking the normal leaf, *T* the tuber in its axil, *L′* the leaf on the tuber. The stem to the right shows the secondary stem from the tuber, marked S′.

The plant grew in the open garden, and, so far as light and moisture were concerned, was not different from hundreds of others that surrounded it. The tubers were preserved and planted in the following spring, but they were very late in sprouting, and some of them rotted without sprouting. Those that produced plants were caught by the hot dry summer, and were attacked by blight before they came to maturity. The plants did not look different from those produced by the ordinary tubers.

Copies of the accompanying photograph were sent to several botanists, who regarded this as an unusual occurrence, though several had seen something like it before. After dismissing the subject for nearly two years, I again came across the photographs, and decided the matter was of sufficient interest to be placed upon record.— W. R. DODSON, *Baton Rouge, La.*

CURRENT LITERATURE.

BOOK REVIEWS.

A text-book of general botany.

THE MAKING of a book is now looked upon as almost reprehensible, and the writer is mentally challenged by his fellows to show valid reason for its publication. The new *Text-book of general botany*[1] must answer this challenge, which is the more peremptory in view of the large claim made by a title devoid of any limitation.

We turn to the preface to learn what the author has to say in justification of his book and the standards by which he wishes it judged. We are told that "the work is intended as an introduction to the study of botany"; and that "the text is based upon the laboratory work required of beginners at Columbia of which it is but an exposition, being supplemented by an extended course of lectures and prescribed reading." In view of its introductory character, would it not have been well to select a title less comprehensive, one by which the book might be more justly designated?

The statement regarding the relation of the book to the work prescribed for beginners in Columbia University is of much interest from a pedagogical standpoint. In order to understand this, it must be said, that, after presenting a group of facts, Dr. Curtis gives general directions for laboratory examination of plants illustrating them. Accompanying this is a list of reference books, in which, presumably the prescribed reading is assigned. The laboratory outlines cover the subjects of histology, physiology, and morphology, and involve the use of material in large amount, which, we infer from the preface, each student is expected to collect and prepare for himself. We are utterly unable to reconcile this amount of work with the amount of time allotted for its performance, viz., two mornings per week for one year—at most 300 hours! Dr. Curtis must have students with extraordinary powers of accomplishing work if *half* that here laid out is really done in a year. Does he realize that he has called for nearly sixty histological preparations, over thirty physiological experiments, and a more or less complete morphological examination of about one hundred plants? In this reckoning we have included as two plants such a direction as this:

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[1] CURTIS, CARLTON C.: A text-book of general botany. Large 8vo. pp. viii + 359; figs. 87. New York: Longmans, Green & Co. 1897. $3.

> Compare *Marsilea* and *Isoetes* with *Pteris.* Do they differ as to growth, branching and leaf arrangement? Which has the highest type of leaf and stem? Has each the homologue of the sorus, indusium, sporangium and annulus? Are the sporangia situated as in Pteris? Is the arrangement of the two kinds of spores the same in both genera?

How many hours will that take? And how many, the comparison of Equisetum with Pteris, requiring eight microscopical preparations (of which five are sections) besides observation of the external anatomy? That such directions may be useful we readily concede; but that anywhere they can be carried out in 300 hours, or 600, we must seriously doubt.

It goes without saying that one in Dr. Curtis' position, with adequate facilities at his command, is capable of enumerating the chief facts of botany when he sets about it; accordingly we find in this book a fairly accurate and up-to-date account of plant structure and phenomena. The facts are made coherent by a thread of philosophical theory which stimulates thought on the part of the student and leaves him with an open mind. The book may therefore serve a good purpose as a reference book in laboratories, particularly as it is well illustrated by new figures.

A most important consideration in a work for beginners is the presentation of the subject. As to manner, this is somewhat unfortunate. Dr. Curtis' English syntax is not above reproach, and his use of words is frequently inelegant or even incorrect. As to matter, it may be questioned whether histology is well adapted for introducing the beginner to the science of botany. What advantage has it over "analysis" which we all decry? Ought not the student's first impression of the plant rather be of an *organism*, capable of *doing* something? Has he at the outset any knowledge which can illuminate the details of histology and make them interesting and intelligible? If it be replied that the student must know structure before he can understand function, it is granted; yet his knowledge of structure must not be deadened by study of detail, it must be vivified study of action.

Through these considerations we are led to the conclusion that the book before us is a convenient compendium of the well-known facts of botany and a laboratory guide with useful suggestions as to illustrative material. In these things it is no better than its predecessors; and this, together with some faults in plan and execution deprive it of a valid *raison d'être.*—C. R. B.

A manual of botany.[2]

THE first edition of this valuable manual appeared in 1895, being intended to take the place of Bentley's *Manual.* In fact, it was the original intention to make it the sixth edition of that work. The necessity for a second edition in two years speaks well for its usefulness. It is well named a "manual," making no claims as a text-book prepared for any special class of students. In an orderly and very clear way it presents the main facts of the subject, in many parts largely partaking of the dictionary style, which is allowable in a manual. The part which treats of morphology bears the most ancient stamp, being simply Bentley's presentation modified sufficiently to include newer views. In the second edition this is still further revised. The part which treats of classification (407 pages) follows the usual method of treating the thallophytes, bryophytes, and pteridophytes from the morphological standpoint as the basis of a rational classification, and the spermatophytes from an entirely different standpoint. This unfortunate group is presented with its usual dreary list of cohorts, orders, etc., entirely unreadable, and suited only to a strictly taxonomic work. Mr. Green, however, is but following the usual custom.

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[2] GREEN, J. REYNOLDS.: A manual of botany. In two volumes. 2d edition. Vol. I. Morphology and Anatomy, xii + 406. *7s 6d.* Vol. II. Classification and Physiology, xi + 541. *10s.* J. & A. Churchill: London. 1897.

In the parts devoted to anatomy and physiology, however, the author appears at his best, for he is in his own field, and one can recognize the touch which has come from personal contact. It seems to us that the chapters on physiology give us the best brief presentation of that great subject which we have met. Compressed as it is into 116 pages out of a total of 947 it is surely entirely out of all proportion. Gladly would we have contributed to its fuller expansion the 220 pages (!) of Benthamian cohorts and orders. We can do little more than give the titles of the chapters which deal with physiology, but even the titles are very suggestive of the treatment. They are as follows: The relation of water to the protoplasm of the cell, the transport of the water in the plant, the skeleton of the plant, the transpiration current (with root pressure and transpiration), the food of plants, the absorption of food materials by a green plant, the chloroplastids and their function, reserve materials, the catabolic processes, the respiration of plants, growth, influence of the environment on plants, the relation of the plant to its environment (with irritability), special sensitiveness and its results, the nervous mechanism of plants, automatism (with rhythm), reproduction.—J. M. C.

Botanical notebook.[3]

THE second edition of this little book has been entirely rewritten, and gives us a good glimpse of the botanical instruction at Brown University.[3] It treats of plants in much the same way as they are presented in Gray's text-books, namely, the gross morphology of spermatophytes. For those who have had no contact with botany this is better than an exclusive use of the compound microscope, but in so far as it suppresses an examination of the lower groups it is incomplete from its own standpoint. The endless lists of names, serviceable only in taxonomy, are not of great educative value; but for those bent upon "analyzing" flowering plants they are a necessary antecedent. We have regarded this phase of botany, so far as elementary students are concerned, as holding the same relation to the science of botany as does the collecting of postage stamps to the science of geography. It is very interesting, and hence very attractive, but it is hardly botany as we understand it today. However, for those who want to do this sort of thing Professor Bailey's book is a most excellent guide, and it suggests some capital work for secondary schools after the pupils have reached the spermatophytes.—J. M. C.

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[3] BAILEY, W. W.—Botanical notebook, a synopsis of lectures and laboratory plans in general morphology and systematic botany for use in classes in Brown University. Second revised edition. 8vo. pp. xi + 120. Preston & Rounds Co.: Providence. 1897.

Practical botany.

THE extensive use made of Professor Strasburger's *Das botanische Practicum*, both in the original and in translations, and in the complete and briefer forms, is evidenced by the numerous editions. It is unusual for a laboratory guide to keep so nearly abreast of current knowledge. A third edition of *Das kleine botanische Practicum* is before us.[4]

As the title indicates, the book is intended primarily for those who are unable to study in the schools under a teacher. It is presumed that the pupil is acquainted with the more recent text-books of botany, and that he has sufficient familiarity with plants to enable him to collect material.

As in the preceding editions, there are thirty-two lessons, but the number of studies under each lesson has been considerably reduced upon the theory that it is better to have a thorough knowledge of a few forms than a superficial knowledge of many. The types considered are about the same as in the last edition, but the exercises have been revised to keep pace with the increasing information on the various subjects. The lesson on bacteria has received special attention. The modern methods of investigation are given in detail, and the form, structure and development of the bacteria are more fully treated than in the previous editions.

On the whole there is an improvement in the technique, the literature also has been brought up to date, and the very complete index adds materially to the value of the book.

The figures are all from Strasburger's own drawings, and nearly all the work, even when it deals with well-known subject-matter, rests upon the author's own investigations.—C. J. C.

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[4] STRASBURGER DR. EDUARD: Das kleine botanische Practicum für Anfänger, etc. Dritte umgearbeitete Auflage. 8 vo. pp. 246. 121 cuts. Jena: Gustav Fischer, 1897. In paper *M* 6, bound *M* 7.

Exercises in botany.[5]

THIS little book, the author states, is designed to supply the need of pupils under the supervision of a teacher who can devote but little time to the subject, and is planned so that the teacher, burdened with other duties, need have little to do in the way of preparing outlines of the daily work. It contains many suggestive facts and various interesting observations not found in similar books. The colloquial and figurative style, which the author adopts to a considerable extent, doubtless aids in holding attention, but seems, at least here and there, to be carried beyond permissible limits in a work devoted to scientific teaching, as, for instance, when it is stated that the embryo of the western peony "does not intend to carry its store of food above ground, ... nor does it risk decapitation at the hands of Jack Frost." In some cases there is more or less obscurity, as in the question, "Which edge of an elm leaf is nearest the twig on which it grows?" And we are reminded of Grant Allen's "high priori" reasoning by the passage, "In short, an apple is good that its seeds may be distributed. A cherry is red that some cherry-loving animal may surely find it and drop its seed far from the parent tree."

On the whole, it may be doubted whether the book is likely to quite fulfill the author's purpose, and a careful examination strengthens the conviction that, however such books may be multiplied, the need of specially trained teachers is thereby increased rather than diminished. In the teacher's library, with others of its kind that are appearing at frequent intervals, it will serve a good purpose in suggesting observations and experiments.— V. M. S.

NOTES FOR STUDENTS.

PROFESSOR D. H. CAMPBELL,[6] has recently investigated the morphology of Naias and Zannichellia. He has confirmed the views of previous observers as to the axial nature of the stamens and ovules, and the mutual relation of leaf, axis, and branch. The stamen of *N. flexilis* is interesting on account of its being surrounded by two envelopes, the inner of which Professor Campbell regards as the homologue of the ovular integument which it greatly resembles, and the outer as corresponding to the carpel of the "female flower." The origin and development of the sexual elements, the growth of the pollen tube, and fertilization do not depart materially from the usual angiospermous type.

The first division of the embryo is transverse, as usual, dividing it into a basal or "suspensor" cell and a terminal or "embryo" cell. The further development of the embryo agrees with Schaffner's account of Alisma as

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[5] RATTAN, VOLNEY.—Exercises in Botany for the Pacific States. The Whitaker & Ray Co., San Francisco. 1897.

[6] Proc. Cal. Acad. Sci. 3d series 1 : 1–62. *pl. 5.* 1897.

opposed to Hanstein's. The suspensor cell enlarges considerably, but remains undivided, and all the embryo and the secondary suspensor cells are derived from the embryo cell which first becomes divided transversely into a number of segments. In *N. flexilis* the terminal segment of the row thus formed gives rise to the cotyledon, the second to the stem, and the third and fourth to the root. In Zannichellia the terminal segment divides vertically, one-half becoming converted into the cotyledon, and the other into the stem, the second, third and fourth segments give rise to the root, and the fifth to the root-cap. The embryo of *N. flexilis* is peculiar in having no trace whatever of a root-cap; that of Zannichellia in the terminal origin of the stem.

The endosperm in both genera is rudimentary. In the later stages of the embryo-sac of *N. flexilis* there is always present near the antipodal cells a large nucleus which increases to an enormous size but does not undergo division. Since Professor Campbell did not succeed in demonstrating a fusion of the polar nuclei, he is inclined to doubt whether such a fusion takes place, and to regard this large persistent nucleus as one of the unfused polar nuclei. As an alternative explanation he suggests the possibility that this large nucleus may be one of the two originating from the first division of the definitive nucleus. The correctness of the latter explanation would seem to be indicated by the presence in Zannichellia of a similar large nucleus although fusion of the polar nuclei probably occurs, as well as by Schaffner's observation[7] that in *Sagittaria variabilis* there are only two or three derivatives of the lower endosperm nucleus and these enlarge enormously.—W. R. S.

ITEMS OF INTEREST on the subject of insect pollination are given by E. Ule.[8] Observations, made chiefly in Brazil, indicate that *Asclepias Curassavica* is usually pollinated by *Danais Euripus*, "a large red-brown spotted butterfly," whose wings resemble in color the flower of the Asclepias. It is said that this butterfly rarely visits other flowers, though large numbers of nectar-bearing flowers are often found in the same locality. Other butterflies frequently seen in this locality very rarely visit this particular species; but when visiting it were seen to load themselves with pollen just as the *Danais Euripus*, and probably bring about pollination with equal effectiveness though in a smaller number of cases. It is also said that this butterfly has been a constant companion in the migrations of this milkweed as it has spread from America. The caterpillars of the butterfly live and feed upon the plant, but seldom cause any injury to it.

The author cites the above as a case of symbiosis, under the category of mutualism. The Asclepias is pollinated and pays for the favor by giving resting place and food both to the butterfly and its offspring, the caterpillar. Just how far the term symbiosis is to be extended is becoming quite a question. If the above happy case of reciprocity is a true case of symbiosis, we must extend the application of the term to the conditions existing between certain groups of animals and plants. And if we extend it to this we shall be well on the way toward saying that the relations between plants and animals at large give us a gigantic illustration of symbiosis. There are many who are disposed to limit the term symbiosis to those more intimate relationships of organisms, cases of actually living together, the "commensaux" condition. As to how far the term shall be extended to those cases where organisms are dependent upon each other for a brief period, mutually or otherwise, becomes a question of degree rather than content.—O. W. C.

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[7] BOT. GAZ. 23:267. 1897.

[8] Ber. der deutsch. bot. Gesellschaft 15: 385–387. 1897.

AN IMPORTANT contribution to the bacteriology of plant diseases has been made by Dr. Erwin F. Smith[9] in a study of brown rot in various cruciferous plants, especially in turnips, cabbage, and kale. A yellow, motile germ, of micrococcus-like appearance, has been isolated and its behavior in the laboratory under various conditions tested. It is aerobic, produces no gas or acid, and forms no spores.

In the cruciferous host it is chiefly found along the fibro-vascular bundles, especially in the vessels, and brings about a characteristic brown discoloration not shown when grown upon other media. A very interesting observation was made in reference to its dispersion within the host. It travels along the vascular strands with readiness, but passes from one to another through the intervening parenchymatous layers with difficulty. The inhibitory condition appears to be due, in part at least, to the acidity of the parenchymatous sap, the organism preferring the alkaline fluids of the bundles.

Many interesting, novel and important details of the study cannot be even alluded to in this connection. The work has established beyond any seeming possibility of cavil another marked disease of plants caused by parasitic bacteria.

The natural infection appears to be through the leaves, partly by the gnawing of worms and insects, and partly by the entrance of the germs through the water pores when root pressure fills them with sap. The disease is apparently widespread, and of considerable economic importance. It does not break down the tissues to any marked extent, but beside producing a discoloration it checks the growth, and often causes the leaves to yellow and drop, making the crop a failure. There is a curious omission of reference to the researches of Dr. H. L. Russell on this disease, some of which have already been published, as well as to those unpublished of which Dr. Smith was fully cognizant. We reserve further comment upon this matter until the publication of Dr. Russell's paper, of which advance sheets have reached us. —J. C. A.

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[9] SMITH, ERWIN F.—*Pseudomonas campestris* (Pammel), the cause of a brown rot in cruciferous plants. Centr. f. Bakt. Par. u. Infekt. 3: 284–291. 408–486, *col. pl. 6.* 1897.

THE *Journal of Botany*[10] has reprinted from the 15th Ann. Rep. of the Fishery Board of Scotland some observations by Mr. George Murray on the plankton of the west coast of Scotland. Mr. Murray finds the bulk of this free-floating vegetation to consist of about ten species of diatoms and a few Peridineæ. In the early months of the year diatom life prevails, reaching its maximum aboat the first of April; in the latter part of the year Peridineæ forms predominate, culminating in August. During the entire year the most favorable zone for diatom development was at a depth of five fathoms, with the prominent exception of *Skeletonema costatum*, which was practically confined to the surface in March and April. Mr. Murray's observations go to prove that small crustacea live almost entirely upon diatoms. Such species as have spines, and the Peridineæ forms, do not serve apparently as daily food for the lower forms of animal life. Besides the ordinary division and the formation of auxospores, reproduction of diatoms by means of endogenously formed spores or endocysts was observed. In some cases as many as sixteen of these reproductive bodies were produced in one diatom, and in summer they were found with unsilicified membranes, dissociated from the parent and undergoing further division. Later in the season forms like the parent reappeared.—H. W. L.

L. A. GAYET[11] has recently completed a monograph on the development of the archegonium in the bryophytes. The article occupies about one hundred pages and sets forth the results of six years' work. A few of the most important points are as follows. The terminal cell, often called the cover cell, contributes to the growth of the neck of the archegonium in the Hepaticæ as well as in the Musci, although the terminal cell is much more active in the latter. The terminal cell does not give rise to neck canal cells either in the Hepaticæ or Musci, but all the neck canal cells are of the same origin, and come from an initial detached from the mother cell of the oosphere. There are also observations on the pedicel cell, the number of neck canal cells, and the number of longitudinal rows in the neck. There are occasionally two ventral canal cells in Sphærocarpus. In one case the ventral canal cell of Marchantia was fertilized instead of the oosphere.

The development of the archegonium of the Anthoceroteæ is so different from that of other bryophytes that the author makes the Anthoceroteæ a group coordinate with Hepaticæ and Musci, and places it, not in its usual position just preceding Musci, but between the Musci and pteridophytes. He believes that the group is more nearly allied to the pteridophytes than to the Hepaticæ.

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[10] Jour. Bot. 35: 387–395. 1897.

[11] Recherchés sur le developpement de l'archegone chez les Muscinees. Ann. Sc. Bot. VIII. 3: 161–258. 1897.

An artificial key to the Hepaticæ, Musci, and Anthoceroteæ is given, based entirely upon archegonium characters. This recalls Treub's effort to base a classification upon chalazogamy.

No mention is made of Campbell's recent book upon mosses and ferns, although quite an extensive bibliography is given. A perusal of this book would probably have added to the value of M. Gayet's monograph.—C. J. C.

WIESNER has made another valuable addition to his various studies on the influence of rain on the plant world. Readers of the GAZETTE will remember in this connection his studies on ombrophilous and ombrophobous organs.[12] His latest work has been to observe the mechanical influence of rain on plants.[13] After referring to the researches of Jungner and Stahl on the adaptations of tropical leaves to rain, the author refers to the common view among botanists that rain works mechanical injuries on plants, although this view is based wholly on theory rather than on actual experimentation.

Wiesner found that the heaviest rain drops, whether in or out of the tropics, weigh but 0.16^{gr}, and that the greatest velocity attained is but 7^{m} per second. Hence the "greatest living force" possible is but 0.0004^{kgm}. Rarely more than six heavy drops fall per second on a space of $100^{sq\,c}$. Water poured from a watering can so slowly as to strike the ground in drops has from fifty to one hundred times this force. The author then records experiments on leaves and flowers and finds, for example, that the corolla of *Impatiens noli-tangere*, when placed on a firm support, is injured by a sphere of lead weighing one gram falling 4^{cm} ($=0.000004^{kgm}$); while swinging free in nature it requires a force of 0.08^{kgm} to produce an injury, *i. e.*, a force 20,000 times as great, and a force 200 times as great as that exerted by the severest rain! Similar results are obtained from all experiments, so that the author concludes that leaves and flowers are practically never mechanically injured by rain alone where swinging free in nature. This conclusion might be reached *a priori* from the fact that tropical leaves, which are exposed to more rain than plants of our latitude, are nevertheless less adapted to stand mechanical injury; for example, they absorb water more freely, thus becoming less protected from mechanical impact, and even when dry they are more readily perforated than our ordinary leaves.

While rain produces little or no mechanical injury when unaccompanied by wind, the destruction due to wind and rain combined is quite patent, but although the water may here do actual mechanical harm, the wind rather than the rain is to be regarded as the real cause. The rain of itself produces injury, not mechanical but of a secondary nature; the fall of leaves several hours after a rain may be regarded as due to the fact that the organic separation of the leaf from the tree is hastened by the increased turgescence caused by the rain.—H. C. C.

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[12] BOT. GAZ. **20**: 112. 1895.

[13] Untersuchungen über die mechanische Wirkung des Regens auf die Pflanze. Ann. Jard. Bot. Buit. **14**: 277–353. 1897.

A RECENT PAPER by Kny[14] confirms the earlier work of Boussingault and Jodin, in affirming a close dependence of the chlorophyll function upon the living plastid and the cytoplasm. The author used as test fluids various blue solutions which had been decolorized with sodium hydrosulfite. Any free oxygen which might be present was driven off by heating, and the liquid again decolorized. This precaution had apparently been neglected by Regnard, who had employed similar methods. Engelmann's bacteria test was also used, this being a very delicate indicator of the presence of oxygen.

In studying chlorophyll separated from its living matrix, its solution in olive oil, or dried into absorbent paper, was used, also portions of plants killed by scalding or drying. All the tests agreed in finding no oxygen liberated during isolation. The results of experiments upon living chloroplastids removed from cytoplasm do not agree with those obtained by Engelmann, Haberlandt, and Pfeffer. Plastids from plants liberated oxygen in no case except where cytoplasm was adhering to them.

Certain external influences were next applied in order to note their comparative effects upon the cytoplasm and chlorophyll function. Plasmolysis did not stop the activity of chlorophyll as long as the protoplasm showed no plain sign of dying. Electricity, moderately applied, had a stimulating effect. Tapping upon the object under the cover glass gave varying results. The ability of plastids to resume activity after having been dried depended on the life habits of the plant, lichens and mosses showing a marked contrast to spirogyra, for example. A temperature of about 50 checked the work of photosyntax before the cytoplasm and chromatophore were perceptibly altered. By shortening the time of exposure sufficiently, these last results were practically reversed. Chloroform affected cytoplasm and chromatophore before the chlorophyll function was checked. The same thing was observed when weak solutions of ammonia and of nitric acid were applied. The general conclusion from these experiments is that the injury to the chlorophyll function does not proceed parallel to that of the cytoplasm and nucleus.—W. D. M.

[14] Die Abhängigkeit der Chlorophylfunction von dem Chromatophoren und vom Cytoplasma. Ber. d. deutsch. bot. Gesells. **15**: 388–403. 1897.

NEWS.

THE ATTENTION of contributors is called to the new regulations concerning separates, which are announced in this number of the GAZETTE.

MR. B. E. FERNOW, Chief of the Division of Forestry, has been called to Hawaii to make a reconnoissance and to report concerning desirable forestry legislation.

MR. FRANCES RAMALEY, Instructor in Pharmaceutical Botany, in the University of Minnesota, has been appointed Assistant Professor of Botany in the University of Colorado, Boulder, Colo.

PROFESSOR G. F. ATKINSON has been experimenting upon plants with the Röntgen rays, and has published a preliminary report in *Science* (January 7). No conclusions are reached, as might be inferred from the following statement: "The longer my experiments continued the more mysterious the whole subject seemed."

THE proposed "Society for Plant Morphology and Physiology" was successfully organized at Ithaca at the recent meeting of the American Society of Naturalists and affiliated societies. A full account of this meeting, both as to the organization of the society and as to the papers read, will appear in the February number of the BOTANICAL GAZETTE.

THE COLLECTION of plants and literature made by the late Professor L. N. Johnson, of Ann Arbor, are offered for sale. Professor Johnson was especially interested in algæ, particularly the desmids, and had published a number of papers concerning them. The writer has inspected the list of books and papers and finds the alga literature well represented.

IT IS reported in *Science* that ground was formally broken for the museum building of the New York Botanical Garden, on December 31. The contract for the construction and equipment of the museum building, power-house, and minor buildings, has been awarded for $347,019. The plans for the great range of horticultural houses have been completed, and specifications for them have been printed. During the past season about 2900 species of plants have been obtained, together with large quantities of museum, library, and herbarium material.

THE PRESS REPORTS of the burning of Pardee Hall at Lafayette College stated that the entire collection of Dr. Thomas C. Porter had been destroyed.

A private letter from Dr. Porter informs us that the greater portion of the collection was saved, but with a good deal of damage from fire and water. An immense amount of labor will be necessary to prevent further loss and to bring order out of confusion. The separate collections from Pennsylvania were not seriously injured, so that Dr. Porter will not be hindered in the completion of his *Flora* of the state. The loss in the botanical library was considerable.

THE COMPLETE HERBARIUM of the late Mr. M. S. Bebb has been purchased by the Field Columbian Museum of Chicago, including his letters, manuscripts, sketches, drawings, etc. The material of Mr. Bebb's own collecting was always known for its perfect preservation, but aside from the large general collection the special value of this purchase is to be found in the unique collection of Salix material. The botanical department of the Museum, under the direction of Dr. C. F. Millspaugh, is to be commended for its enterprise in securing collections which will soon make it an important taxonomic center.

AT THE MEETING of the Minnesota Academy of Science, at Minneapolis, December 28–30, 1897, three botanical titles were presented. Professor J. C. Arthur read a paper on "The law of regression in plants," dealing with the tendency of plants to approximate toward mediocrity in size of seed and vegetative body. Professor MacDougal read a paper on the "Development of saprophytism," in which two general methods of variation toward the greater use of organic food were outlined, and another on the "Problems and province of plant-physiology," in which the present status of the subject in teaching and research was discussed.

WE note with regret that with the number (December 29) which completes its tenth volume, *Garden and Forest* suspends publication. The following statement is made: "For ten years the experiment has been tried of publishing a weekly journal devoted to horticulture and forestry, absolutely free from all trade influences, and as good as it has been possible for us to make it. This experiment, which has cost a large amount of time and money, has shown conclusively that there are not persons enough in the United States interested in the subjects which have been presented in the columns of *Garden and Forest* to make a journal of its class and character self-supporting. It is useless to expend more time and money on a publication which can not be made financially successful, and must, therefore, sooner or later cease to exist." This comes as a surprise to the many botanists who had come to regard this as one of their most valued journals.

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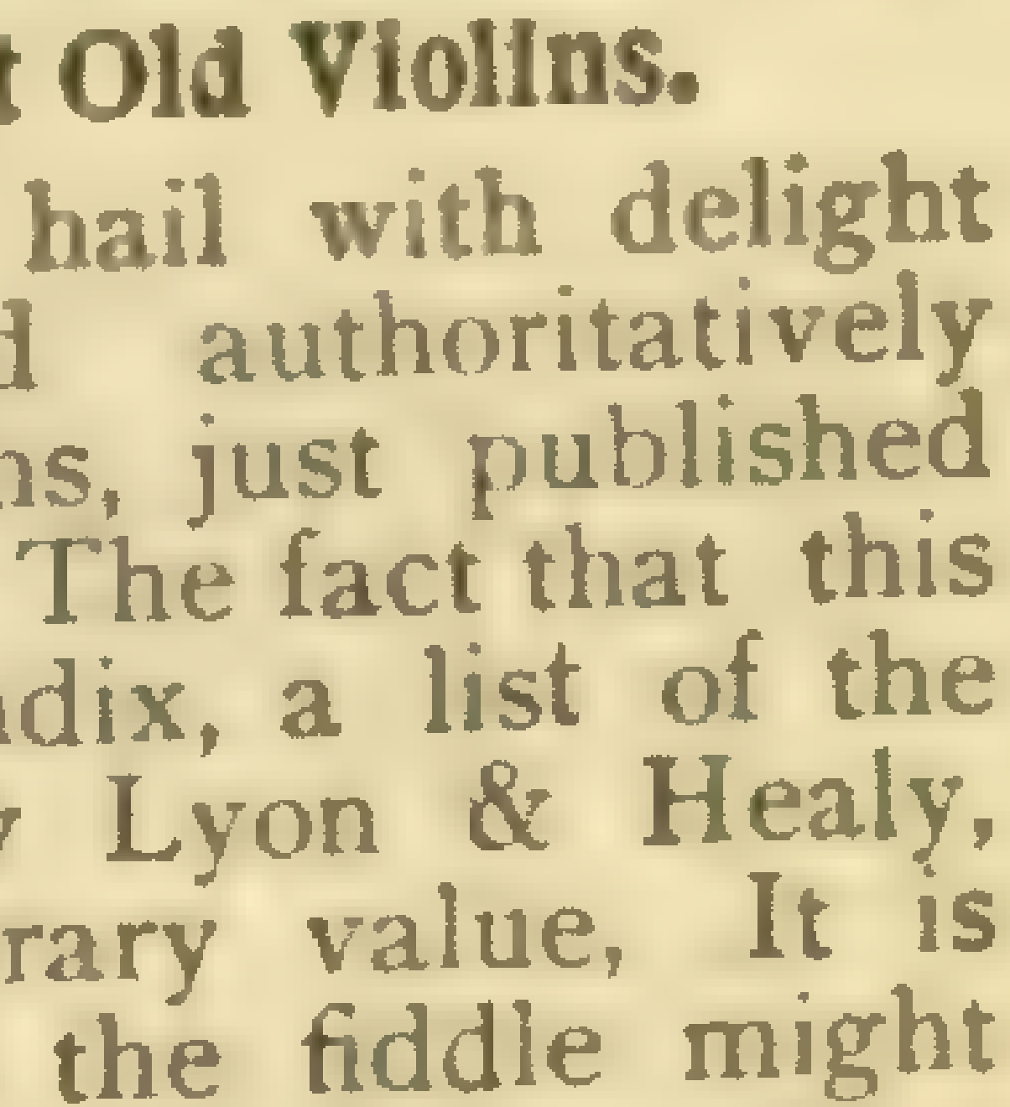

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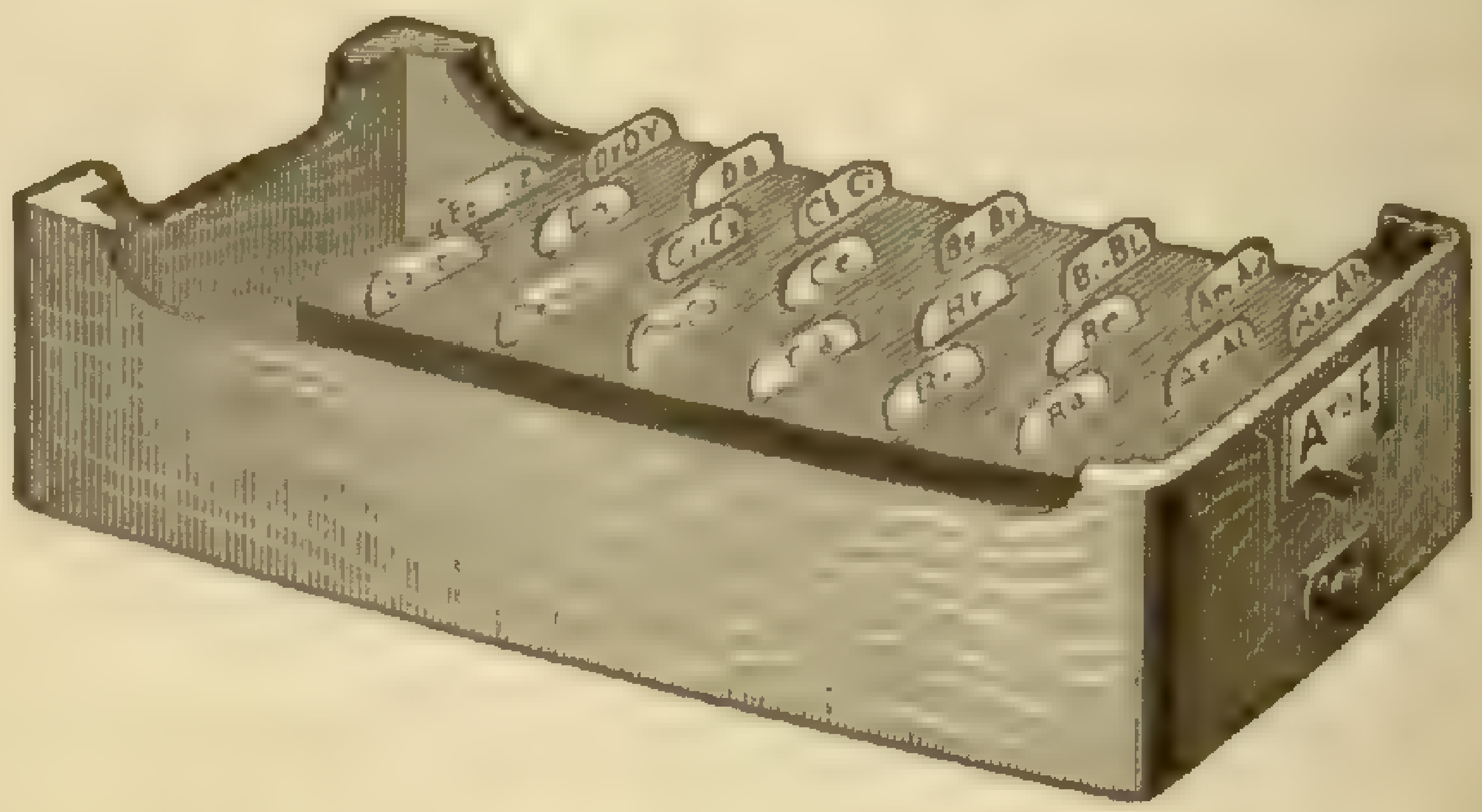

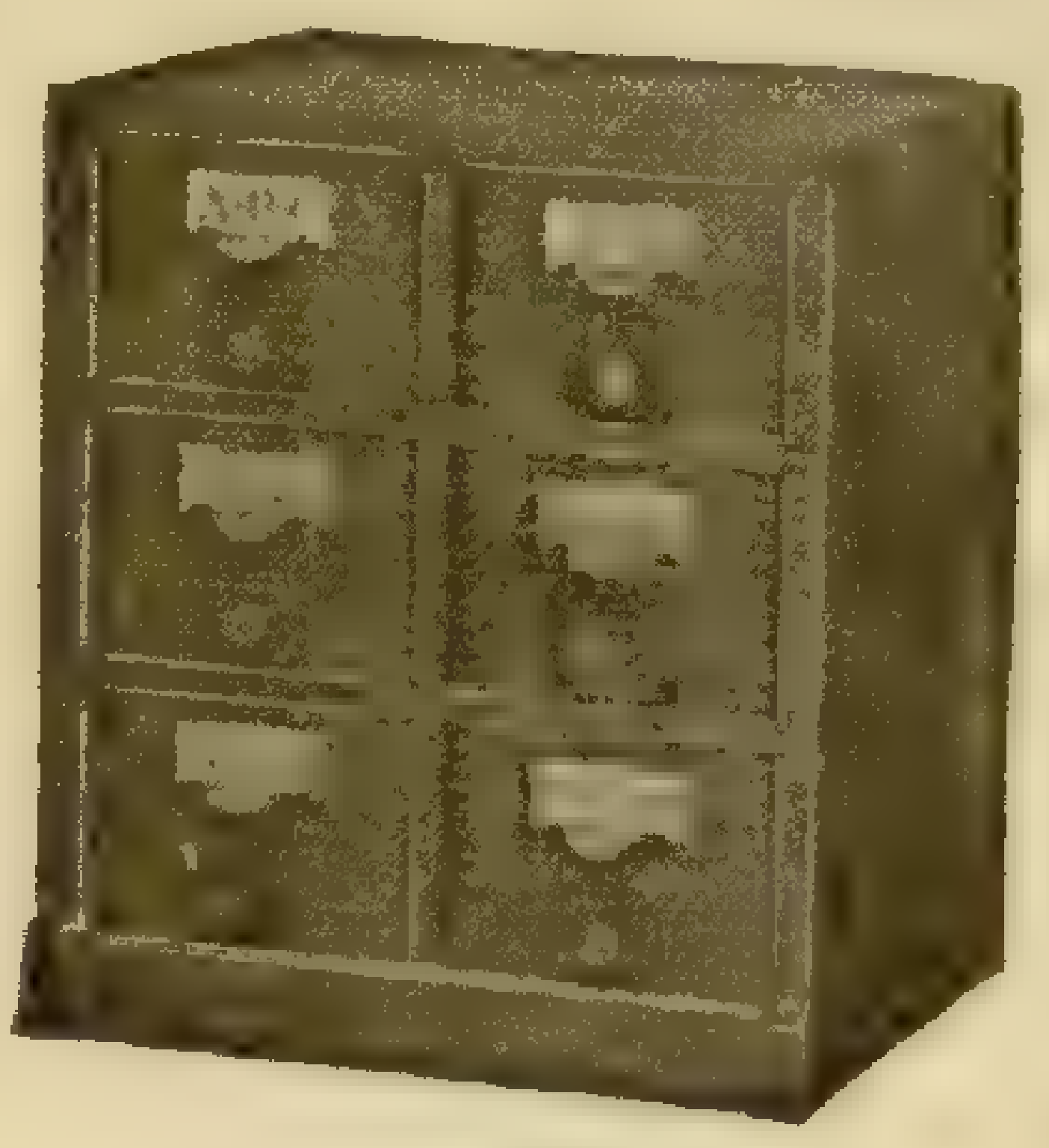

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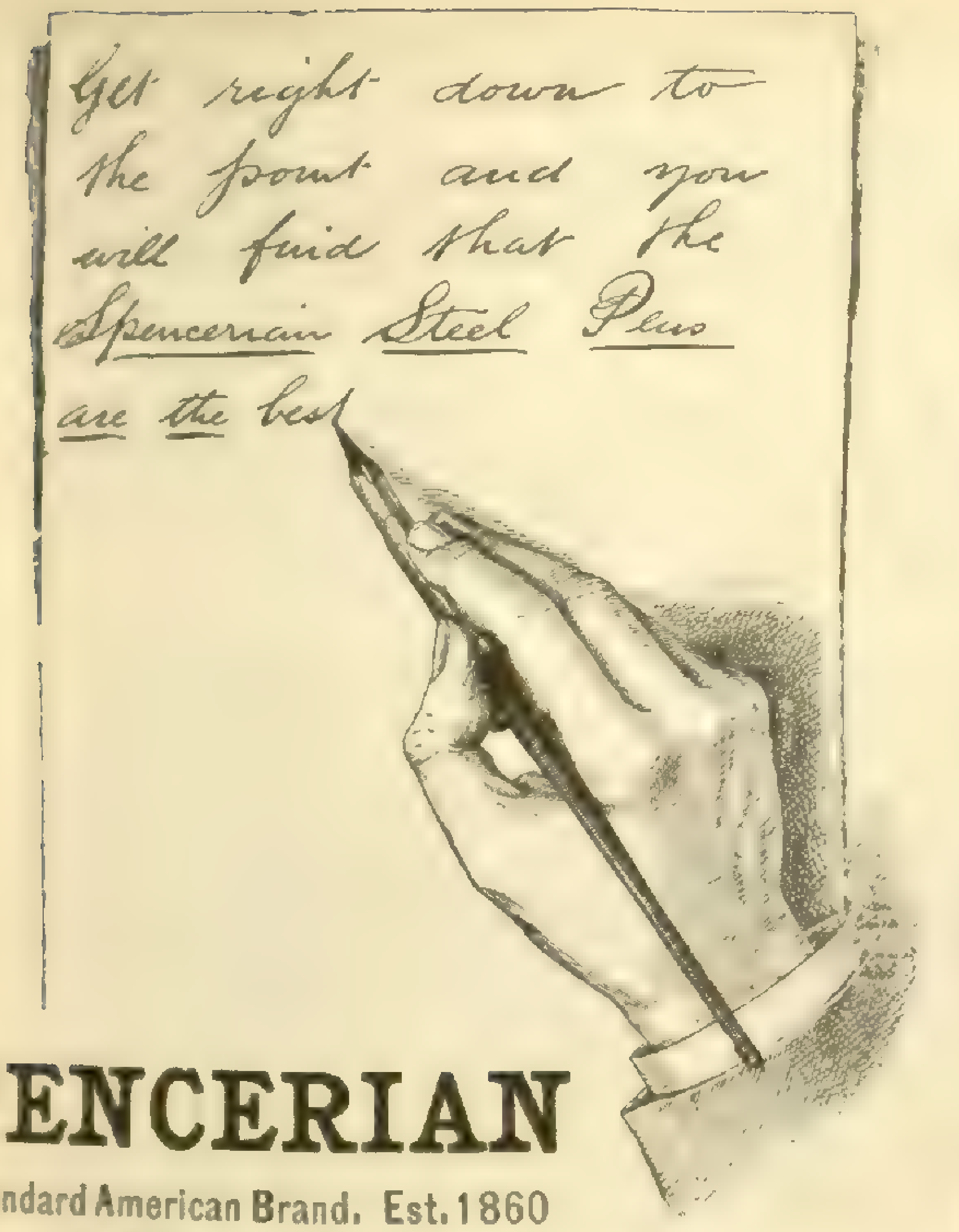
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VOLUME XXV NUMBER 2

BOTANICAL GAZETTE

FEBRUARY 1898

CONTRIBUTION TO THE LIFE-HISTORY OF RANUNCULUS.[1]

JOHN M. COULTER.

(WITH PLATES IV–VII)

In 1896 a group of research students working in the Hull Botanical Laboratory of the University of Chicago began the investigation of a somewhat wide range of spermatophytes. In addition to the individual problems certain representative forms were selected for joint study, among which was Ranunculus. It was felt that a large multiplication of preparations was desirable, in at least a few cases, to discover the possibilities in variation, and this feeling was justified by the result, since very different conclusions could be drawn from different sets of preparations. It is comparatively easy to obtain a definite sequence in the development of structures when the facts are few, but definite sequences seem to disappear as facts multiply.

The species of Ranunculus chiefly studied were *R. septentrionalis*, *R. multifidus*, and *R. abortivus*, and the results obtained were so constant that it would not be profitable to distinguish in every case among the species in the following account. Certain other genera of Ranunculaceæ were examined also, and they contribute to certain conclusions herein set forth.

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[1] Contributions from the Hull Botanical Laboratory. VII. The previous contributions will be found in BOT. GAZ. **20**: 205–212. 1895; **23**: 40–43, 147–179, 252–273, 412–452. 1897; **24**: 93–102. 1897.

It is hardly necessary to refer to the history or literature o this subject, as it has been presented frequently. The pape simply presents certain results obtained from Ranunculus, in reference to structures with whose "normal" behavior morphologists are entirely familiar. It was felt that Ranunculus might be of interest from a phylogenetic point of view, as representing one of the so-called "primitive regions" of dicotyledons.

The usual methods of killing, staining, and sectioning were used, and need no special description.

MICROSPORANGIA AND MICROSPORES.

In the young sporangium a plate of hypodermal cells becomes distinctly differentiated by means of their enlarging radial diamete and prominent nuclei (*fig. 1*). There is great confusion in terminology in reference to these cells and those derived from them and it is in the interest of clear statement to establish homologous parts, so far as possible, and adopt a uniform terminology. In case this is not possible, at least a consistent terminology should be used throughout a single paper or text. Deferring a brief discussion of this matter to the end of the section, I woul regard this plate of cells as the archesporium. Each archesporial cell tends to develop a radial row, and this arrangement remains more or less distinct in spite of certain inequalities o development in neighboring cells. Tracing the development o a single archesporial cell, the sequence of events is very similar to that commonly found in connection with the archesporia cell of the macrosporangium. A periclinal division results i two cells radially placed (*fig. 1*), the outer of which is a primar wall cell and the inner a primary sporogenous cell. From th point, the sequence is variable. Both cells may divide by periclinal walls, or the primary sporogenous cell may divide on in the formation of mother cells. In the former case, the oute cell formed by the periclinal division of the sporogenous cell contributes to the formation of the tapetum. In the latter case the innermost cell derived from the two or three periclinal division of the primary wall cell contributes to the tapetum (*figs. 2,* It would appear that in Ranunculus the cells of the peripheral region of the tapetum may be variable in origin. Of course the tapetal cells on the axial side of the sporogenous tissue cannot in any event be derived from the primary wall cells. The tapetum, therefore, is essentially a morphological composite, and is significant only in its physiological relation to the sporogenous cells. In its peripheral region in Ranunculus it may be derived from the primary wall cell, as in the eusporangiate Filicineæ; or from the primary sporogenous cell, as in the leptosporangiate Filicineæ. In its axial region it may be derived from the adjacent tissue, or cut off from the sporogenous tissue. In some cases it seemed as though the whole of the tapetum were cut off from the periphery of the sporogenous tissue (*fig. 4*), and in other cases (*fig. 5*) its partial derivation at least from primary wall cells seemed equally clear. In the case of an archesporium consisting of a single longitudinal row of cells, as in Cnicus, it was observed that all the cells of the tapetum, with the possible exception of a single peripheral one, were derived from the adjacent tissue. While there may be uniformity in the origin of the tapetum in some cases, enough was seen of the history of the individual archesporial cells to indicate that the cell of the radial row contributing to the tapetum might be sister to the contiguous sporogenous cell, or to a cell derived from the primary wall cell. In any event, the main fact seems to be that each archesporial cell develops a radial row with a varying number of cells; that the innermost cell of this row is sporogenous; that the outer ones are sterile; and that between the two a special nutritive layer is developed (the tapetum) whose constituent cells are determined by position rather then by origin. In general there are two layers of cells in the wall of the sporangium between the endothecium and the tapetum (*fig. 6*), but the number may vary between one and three in the same wall. The cells of the tapetum are occasionally binucleate (*fig. 4*), but not mostly so, as in many other microsporangia examined. In *Hepatica acutiloba* tapetal cells were observed containing from six to thirteen nuclei.

The primary sporogenous cells do not divide extensively, each cell dividing once or twice, so that the mother cells are only two or three times as numerous as the primary sporogenous cells (*fig. 6*). Disorganization of the tapetum and wall layers begins early, so that the mother cells soon become quite free in the loculus (*figs. 4, 6*).

In the development of microspores the usual sequence of events was observed, an ordinary series being shown in *figs. 7-10*. The four spores may be arranged in the usual tetrahedral fashion (*fig. 11*), or may lie in the same plane (*fig. 12*). In both divisions of the mother cell numerous free nucleoli were observed in the cytoplasm (*figs. 12, 13*), and in some cases the bodies were noted which have been regarded as centrosomes (*fig. 14*). In the mature spore the exospore develops fifteen to thirty thin spots for tube extrusion (*fig. 15*).

In the germination of the spore but a single nuclear division was observed in the spore itself, the tube and generative nuclei being approximately of equal size and form (*figs. 16, 17*). In the figures cited it will be noted that the organization of the two into distinct cells has not been accomplished. In Caltha the same division was observed, and upon the complete organization of the generative cell it assumed the usual lenticular form. This form may involve the nucleus itself, or it may be due entirely to the aggregation of the cytoplasm in polar position, the whole distinctly invested by a "Hautschicht."

The term archesporium must either be restricted so as to apply only to those cells which produce mother cells or their equivalents, or it must be extended so as to include those differentiated cells which produce wall cells, tapetum, and sporogenous cells. It is in the latter sense that the term has been used above. This has seemed the more desirable use of the term, as it is far more definite and easy of application. Such a cell is distinctly differentiated, but its progeny may vary considerably, and in the case of Ranunculus the restricted use of archesporium might or might not involve the tapetum.

In the first division of an archesporial cell, in its larger application, the exterior cell has been called the "primary wall cell," as its derivatives enter into the formation of the wall; rather than the "primary tapetal cell," as its derivatives may or may not contribute to the tapetum. The interior cell resulting from the first division of an archesporial cell is well called a "primary sporogenous cell," as the sporogenous tissue is derived from it, and often nothing else is.

This very customary use of the term archesporium in connection with the microsporangia of spermatophytes, when logically applied to the macrosporangia of spermatophytes and the sporangia of other groups, leads sometimes to a terminology not at all customary. In the case of the macrosporangia of spermatophytes the term archesporium is applied in the same broad sense to the first distinctly differentiated cell. In this cell a periclinal division may or may not take place. If it does occur, as is usual, the exterior sterile cell has been called a tapetal cell, whether it functions as a tapetum or not, and whether it divides further or not. It seems evident that we have here the homologue of the primary wall cell of the microsporangia, which may form several layers, to call all of which a tapetum seems very questionable. In this case it is a question whether the problematical so-called "potential macrospores" do not function as tapetal cells, in which case the "fertile macrospore" may be regarded as the only real sporogenous cell. In view of the uncertain nature of these structures, however, no such terminology is adopted, and the current view that they are spore mother cells is retained.

In such sporangia as those of the eusporangiate Filicineæ, however, a similar application of the term archesporium changes its usual application. The distinctly differentiated superficial cell becomes in this case the archesporium, and the usual periclinal division separates the exterior primary wall cell from the interior primary sporogenous cell (not archesporium).

In the case of such extremely modified sporangia as those of the leptosporangiates, the archesporial cell functions as an apical cell in the development of the stalk, but the usual periclinal division finally separates an exterior primary wall cell from an interior primary sporogenous cell. In this latter case the tapetal layer is evidently cut off from the sporogenous cell but we have seen that this may occur in other groups as well.

Such an application of the term archesporium has the merit of uniformity and of fairly homologizing its derivatives. It has seemed to me that the term tapetum should disappear as a morphological term, inasmuch as it is a physiological layer between the sporogenous cells within and the sterile cells without, and of variable origin, derived from the wall cells, or from the sporogenous cells, or from the cells of the adjacent tissue.

MACROSPORANGIA AND MACROSPORES.

In the case of *R. septentrionalis* a single hypodermal cell frequently represents the whole of the archesporium (*figs. 18–22*), soon becoming very much larger than the contiguous cells, and with a very conspicuous nucleus. Frequently an axial row of cells beneath this archesporial cell, with prominent nuclei, gives the impression of a row of mother cells (*figs. 19, 21*), but the subsequent history of the larger hypodermal cell proves the contrary. In most cases the epidermal cells capping the single archesporial cell divide once by a periclinal division (*figs. 20, 23*), or occasionally twice, making three layers of cells, but this represents all the development of tissue above the sporogenous cells. In this case no primary wall cell (tapetum) is derived from the archesporium.

In many cases, however, instead of a single archesporial cell, a group of cells forms the archesporium. Regarding only those cells which show by their increased size, prominent nuclei, and reaction, that they are of undoubted archesporial nature, numbers varying from two to thirteen were observed (*figs. 24–26*). In *fig. 26* an archesporium of eight cells is shown. In many cases it was hard to define the archesporium exactly, as cells contiguous to those of undoubted archesporial nature, by virtue of their size and general appearance, certainly suggested archesporial character. The evidence is clear that the single archesporial cell of Ranunculus is but the remnant of an archesporial mass of cells, which still appears in various stages of sterilization. In some cases two or three cells of a several-celled archesporium were observed to develop to mature size, but usually not more than one was observed to divide. In certain preparations, however, development of several of the archesporial cells was observed to have proceeded further (*fig. 27*), some developing to the "two-celled" and "four-celled" condition of the embryo sac. In the case of *R. septentrionalis*, on account of imperfect material, only a single stage of development was noted, but as a complete series was obtained from *R. multifidus*, it seems probable that the same division into four mother cells occurs. In no case was a primary wall cell (tapetal cell) cut off, the archesporial cell dividing directly into mother cells.

In *R. multifidus* the sequence of events from archesporium to macrospore was obtained in detail. Indication of an occasional two or three-celled archesporium was also observed (*fig. 28*). The series of changes from the archesporial cell to the axial row of four mother cells is represented in *figs. 29–32*, and in every case observed the lowest cell of the series developed the macrospore.

In *R. abortivus* the same stages were observed. *Fig. 33* represents a notably well-developed archesporium of two cells, while *figs. 34* and *35* indicate the same steps in the development of the macrospore as those observed in *R. multifidus*. In the last two figures the condition of the integuments indicates the stage of the ovule in which the sporogenous development occurs.

In its earliest condition, after distinct differentiation, the macrospore of *R. septentrionalis* is almost globular (*fig. 36*), with prominent nucleus and nucleolus. Soon it begins to elongate in the direction of the long axis of the nucellus, with enlargement of the nucleus and characteristic ante-division nuclear changes (*fig. 37*). In some cases the macrospore becomes so much elongated as to be cylindrical. The series of nuclear divisions which occur in the macrospore is indicated in *figs.*

38–42, in which may be noted also the constant development of a large vacuole separating the micropylar and antipodal nuclei. The preparations of *R. multifidus* were much more favorable for a study of the mature condition of the embryo sac than those of *R. septentrionalis*. The series shown in *figs. 43–47* may be taken as fairly representative of the mature sac in *R. multifidus*. The strong development of the antipodal cells is a notable feature, distinct walls being developed, the cells enlarging in size and giving evidence of great activity until late in the endosperm formation. The formation of the very large definitive nucleus is plainly shown, and its placing near the oosphere. The general insignificance of the nuclei of the egg apparatus as compared with the others, and their relatively late organization into cells, is at once remarked, synergid nuclei being especially small. In *figs. 43–46* the fact that the synergids are sister cells is evident, and the shifting position of the micropylar nuclei can be traced.

The prominence and activity of the antipodal cells is more marked in certain other ranunculaceous plants than in Ranunculus itself. *Thalictrum purpurascens* and *Hepatica acutiloba* (*fig. 48*), can be taken as illustrations. Associated with the growth of these cells is the usual abundant nuclear division, which, although in every case apparently mitotic, is more or less irregular, as indicated in *figs. 49, 50*, both of which represent the antipodal cells of Hepatica.

It has long since become evident that the most variable region of the embryo sac in dicotyls, preceding fertilization, is the antipodal region. The old formula of three dwindling and evanescent cells, with or without walls, is far from adequate. Such a statement seems to be more true of monocotyls than of dicotyls. In the latter I am able to distinguish at least four distinct types of antipodal development, with the vast majority of forms yet to be investigated. These types merge into one another, but are distinct enough in their extreme expression.

1. A group of evanescent cells, usually three in number. These cells seem to take no part in the activities of the sac, and often disappear so quickly as to give rise to the impression, in

some cases, that no antipodals are formed. In fact, the claim of no antipodals should suggest the probability that the observer is dealing with the evanescent type. So far as researches have gone, this type is characteristic of the Amentiferæ and their allies, is found in Acer, etc.

2. Three large antipodal cells, increasing in size with the sac, sometimes extending almost half through its long diameter, apparently very active, and not disorganizing until after the embryo has begun to develop. This growth of the antipodals is usually associated with extensive division of the nuclei, mostly mitotic in our observations, but undoubtedly sometimes direct. This type is quite characteristic of the Ranunculaceæ and their allies.

3. Usually three comparatively permanent cells, not notable in size or activity, and usually associated with a sac decidedly narrowed at the antipodal end. This type is rather common among the Sympetalæ.

4. An indefinite number of cells, forming a relatively permanent and very prominent tissue, often continuing its growth downwards and breaking through the bottom of the sac. In this somewhat extensive growth the lowest cell is apt to become very large and vesicular, and multinucleate. This type is associated with a narrow, elongated sac, and is quite characteristic of certain sections of the Compositæ, notably the Asteroideæ.

FERTILIZATION.

The phenomena of fertilization are the usual ones, but certain features seem worthy of mention. The pollen tube, after its entrance into the embryo sac, increases rapidly in diameter, in some cases forming a pouch-like tip remarkably large as compared with the caliber of the tube behind (*fig. 51*). The tube passes between one of the synergids and the wall of the sac, and the terminal pouch develops a convex and a concave side, so that the apex of the tube is directed towards the nucleus of the oosphere (*figs. 51, 52*). The tip of the tube apparently breaks down, as in all species we have investigated; at least it lacks sharp definition and presents a frayed appearance. The distance between the two nuclei at the time of the discharge of the male cell is quite variable. In *fig. 52* it will be noted that the male cell has been discharged at some distance from the nucleus of the oosphere, and that the nourishing synergid gives no special indication of disorganization, unless it be found in the disappearance of the nucleolus. The nourishment of the male nucleus, however, during its movement towards the female nucleus, and increase in size, results in synergid disorganization. In *fig. 51* the two gamete nuclei are shown in a fusion stage, but it will be noted that the second male cell has also been discharged in a very disorganized condition. *Fig. 53* shows an undischarged pollen tube.

ENDOSPERM.

The definitive nucleus is remarkably large, and rests either near the oosphere or becomes somewhat centrally placed in the sac (*figs. 46, 47, 52*). Free nuclear division, with more or less cytoplasmic organization, proceeds with great rapidity (*fig. 54*). In the figure just cited the oospore has not yet divided, while six free endosperm cells are represented. The prominence of the antipodal group is also noticeable, as well as its somewhat lateral position, due to the beginning of the remarkably one-sided development of the sac. That this formation of free endosperm cells proceeds not only with rapidity, but in a remarkably simultaneous fashion, is indicated by the great numbers of spindles in practically the same stage (*fig. 55*). The figure cited represents but a portion of the embryo sac. A more detailed view of an endosperm spindle is shown in *fig. 56*, in which the radiations about the poles are remarkably clear. During the formation of free endosperm cells the sac enlarges rapidly, both laterally and downward, but chiefly upon one side, so that eventually the still prominent and active antipodals are on one side of the lower broad end of the sac, and are frequently thrust out conspicuously into the cavity on a stalk-like projection, which represents the original center of the bottom of the sac (*fig. 57*). This is decidedly different from the method of sac development in the monocotyls we have studied, in which the sac enlarges above the base, leaving the dwindling antipodals at the bottom of a pit-like depression, which sometimes is thrust to one side of the center. The one-sided development of the sac is determined by the fact that it is obstructed on one side by the conspicuous fibrovascular bundle, while the other side and bottom are directed towards the free cavity of the ovary.

At this stage of development the endosperm nuclei, formerly distributed through the cavity of the sac, have assumed the parietal position, forming a complete lining layer, interrupted only by the embryo and the antipodal stalk. It will be noted in the figure last cited that the embryo has completed only the first division.

The most interesting phenomenon in connection with the formation of endosperm, however, was the occasional evidence of its formation before the fusion of gametes, and even before the entrance of the pollen tube into the cavity of the sac. In *fig. 58* a preparation is shown in which the large egg is lying in the very apex of the sac, the two synergids being apparent in an adjacent section, and yet free endosperm nuclei are distributed through the sac, and are even assuming the parietal position.

It does not follow, however, that the endosperm begins to form without any stimulus from the pollen tube. The presence of the tube in the style is known to exert a strong influence upon the adjacent tissues, which may well be felt in the embryo sac. The beginning of endosperm formation, therefore, even though observed before the entrance of the pollen tube into the embryo sac, may none the less be definitely related to the phenomena of fertilization, of which the entrance of the tube and the fusion of the gametes are only a part.

The parietal placing of endosperm cells is a phenomenon of orientation which deserves consideration. That the curving of the tip of the pollen tube towards the nucleus of the oosphere and the movement of the male nucleus towards it are phenomena that depend upon chemotropism seems to be a satisfactory explanation; but the parietal placing of free endosperm cells is not to be explained in any such way. The phenomenon may be likened to that observed in connection with certain animals and animal cells, which seek a solid support that seems to be essential to their further activity. In the case of endosperm cells the parietal position is usually antecedent to the formation of cell walls.

EMBRYO.

There seems to be a general rule in the early divisions of the embryo, subject however to numerous exceptions, the causes of which are doubtless accessible. The oospore usually elongates considerably, with the nucleus at the distal extremity, and the vacuole conspicuous. The sequence of events in both *R. septentrionalis* and *R. multifidus* is so nearly identical that they will be considered together. As is to be expected, the first division is transverse, the terminal cell being smaller (often much smaller) than the other (*figs. 59–61*). In the last figure cited a sudden bending of the young embryo from the persistent synergid may be noted. The next division is also transverse, but it may occur either in the basal or apical cell (*figs. 62–65*). In the first figure cited the presence of a spindle in the basal cell definitely establishes the origin of the second wall in this case. There is also evidence that the second division may occur in the apical cell (*fig. 64*). In any event, a row of three cells seems invariable. Usually the third division is also transverse, apparently occurring in any one of the three cells previously formed, forming a row of four cells (*figs. 66–67*). This row of three or four cells uniformly precedes any longitudinal division. It would seem clear in this case that the suspensor may not arise wholly from the basal cell of the first division; and that the apical cell of the first division may contribute to the formation of the suspensor as well as to that of the embryo. After the row of three or four cells has been formed, the first longitudinal division occurs, and, so far as our preparations show, always in the apical cell (*figs. 68–70*). The persistence of the synergid unused in the processes of fertilization is also evident. After the apical cell has divided longitudinally, similar divisions may occur in all other cells of the primary row or in some of them (*figs. 71–72*). This variation in the formation of longitudinal divisions in the suspensor region is apparent even in much older embryos. Occasionally a late transverse division in the basal cell was observed (*fig. 73*).

The most advanced stages of the embryo studied show considerable development of the suspensor, and the complete cutting off of a peripheral region of the embryo by periclinal walls, but no differentiation of the organs of the embryo.

The students who contributed preparations and drawings to this paper are O. W. Caldwell, T. C. Frye, Florence M. Lyon, W. D. Merrell, Mabel L. Merriman, J. H. Schaffner, and W. R. Smith. Their initials in connection with the drawings indicate the individual contributions. The laboratory work and the preparation of the plates were cared for by Dr. C. J. Chamberlain.

THE UNIVERSITY OF CHICAGO.

EXPLANATION OF PLATES IV–VII.

The drawings have been reduced to three-eighths of their original size, and were made with an Abbé camera. Unless otherwise indicated the ocular combination was Reichert ocular 4 and Bausch and Lomb $\frac{1}{12}$ oil immersion

PLATE IV.

FIG. 1. Microsporangium of *R. septentrionalis*, showing row of hypodermal archesporial cells, in one of which is a spindle of the first periclinal division.

FIG. 2. Microsporangium of *R. multifidus*, in which the sporogenous cells are distinct, and the tapetal layer appears to have been developed from the wall. Leitz oc. 4, obj. 7*a*.

FIG. 3. The same, with anther wall further developed. Same combination.

FIG. 4. Microsporangium of *R. septentrionalis*, in which the prominent tapetal layer seems to be more related to the sporogenous cells.

FIG. 5. Microsporangium of *R. multifidus*, showing a definite relation of tapetal cells to the wall layers, and a differentiation of the endothecium. Leitz oc. 4, obj. 7*a*.

FIG. 6. Microsporangium of *R. septentrionalis*.

FIGS. 7–11. Development of microspore tetrad in *R. septentrionalis*.

FIG. 12. Second nuclear division in pollen mother cell, occurring in same plane, and showing free nucleoli and kinoplasmic threads. Zeiss oc. 18, obj. 2^{mm}.

FIG. 13. First nuclear division in pollen mother cell of *R. multifidus*, showing free nucleoli and polar radiations. Leitz oc. 4, obj. $\frac{1}{12}$.

FIG. 14. First nuclear division in pollen mother cell of *R. multifidus*, showing "centrospheres."

FIG. 15. Microspores of *R. septentrionalis*, showing thin areas in the exospore. Leitz oc. 4, obj. 7*a*.

FIGS. 16, 17. Mature microspores of *R. septentrionalis*, showing the two nuclei.

FIGS. 18–20. Macrosporangium of *R. septentrionalis*, with single archesporial cell; in *fig. 20* a periclinal division is represented in the overlying epidermal cell.

FIG. 21. The same, showing subjacent row of cells in the sporangium sometimes mistaken for a row of mother cells.

FIG. 22. The same, showing enlargement and first nuclear division.

FIG. 23. The same, showing the first division completed.

FIGS. 24, 25. Archesporium of *R. septentrionalis*, composed of more than one cell.

PLATE V.

FIG. 26. Macrosporangium of *R. septentrionalis*, with eight-celled archesporium.

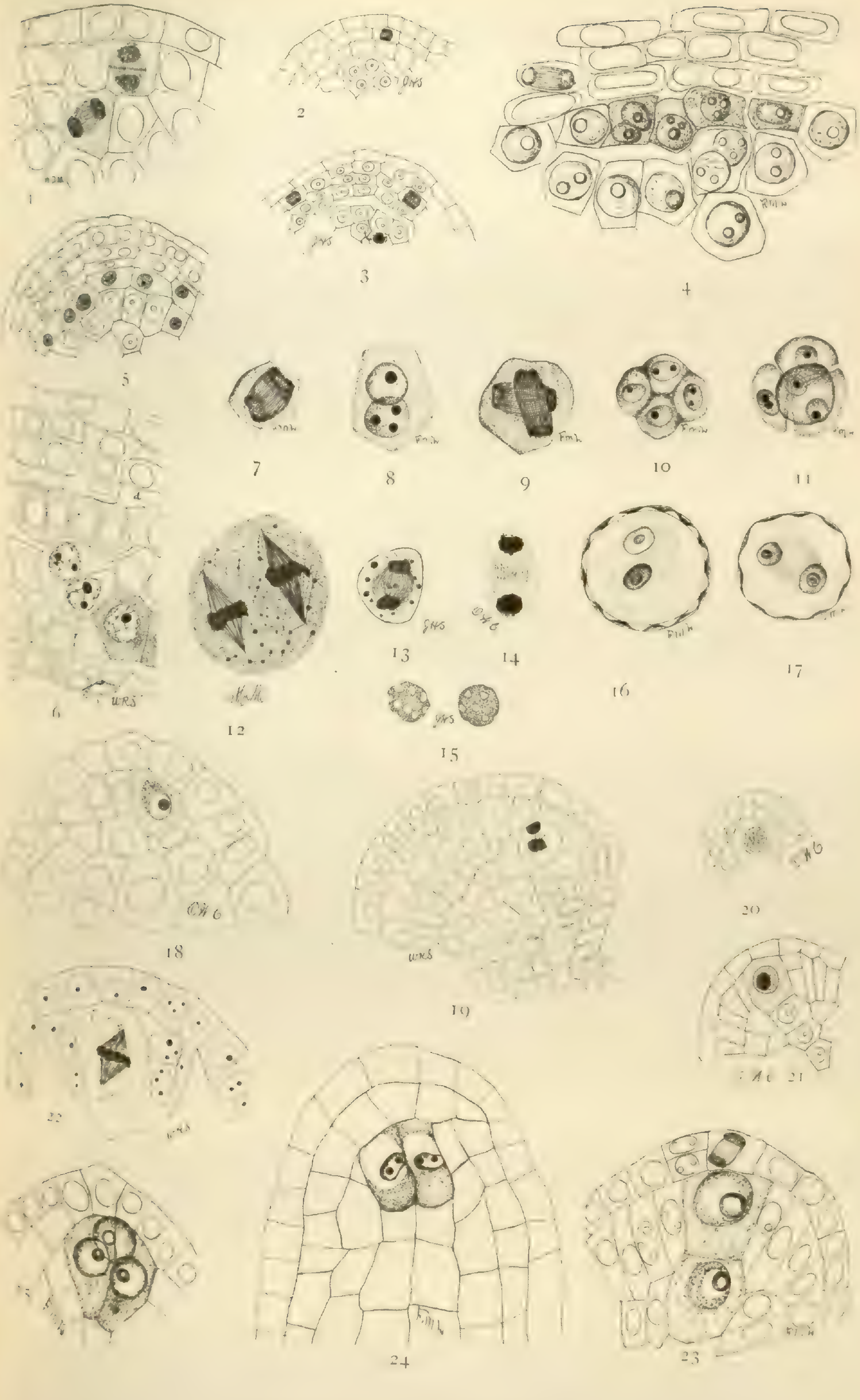
FIG. 27. The same, with three archesporial cells in an advanced stage of development, the two to the right in the "two-celled" and "four-celled" stages of the embryo sac. Zeiss oc. 4, obj. 2^{mm}.

FIG. 28. Macrosporangium of *R. multifidus*, with the remains of a second archesporial cell.

FIGS. 29–31. The same, showing successive stages in the development of the row of four mother cells.

FIG. 32. The same, showing the beginning of the enlargement of the fertile mother cell, and the destruction of the adjacent cell.

FIG. 33. Macrosporangium of *R. abortivus*, showing a two-celled archesporium.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COULTER on RANUNCULUS.

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PML
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WRS
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WDM
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WRS
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TCF
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FML
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FV
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FML
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COULTER on RANUNCULUS.

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COULTER on RANUNCULUS.

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COULTER on RANUNCULUS.

FIGS. 34, 35. The same, showing first and last stages in the development of the mother-cell row.

FIGS. 36–40. Stages in the nuclear divisions of the embryo sac of *R. septentrionalis* (except *fig. 39*, which is from *R. multifidus*). In every case the micropylar end is the upper one. In *fig. 40* the antipodal spindle shows polar radiations at one end and a multipolar character at the other. Zeiss oc. 18, obj. 2^{mm} (except *fig. 39*).

PLATE VI.

FIG. 41. Embryo sac of *R. septentrionalis*, showing completion of the second nuclear division. Zeiss oc. 6, obj. 2^{mm}.

FIG. 42. The same, showing spindle of the third division. Zeiss oc. 4, obj. 2^{mm}.

FIGS. 43–46. A series from the embryo sac of *R. multifidus*, showing fusion of polar nuclei and the organization of the egg apparatus. Zeiss oc. 6, obj. 2^{mm}.

FIG. 47. Mature embryo sac of *R. multifidus*.

FIG. 48. Mature embryo sac of *Hepatica acutiloba*.

FIG. 49. Antipodal cells of *H. acutiloba*, showing extensive unequal mitotic divisions. Zeiss oc. 6, obj. 2^{mm}.

FIG. 50. The same, Zeiss oc. 8, obj. 2^{mm}.

FIG. 51. Embryo sac of *R. septentrionalis*, showing pollen tube, fusion of sex nuclei, and the disorganized but discharged second male cell.

FIG. 52. Embryo sac of *R. multifidus*, showing discharge of male cell at some distance from the oosphere nucleus, also the very large definitive nucleus.

FIG. 53. Embryo sac of *R. septentrionalis*, showing undischarged pollen tube approaching the oosphere nucleus.

PLATE VII.

FIG. 54. Embryo sac of *R. multifidus*, with free endosperm nuclei and an undivided oospore. Zeiss oc. 18, obj. 2^{mm}.

FIG. 55. The same, showing simultaneous formation of endosperm spindles. Zeiss oc. 6, obj. 2^{mm}.

FIG. 56. An endosperm spindle of *R. multifidus*, showing very clear polar radiations. Reichert oc. 12, Leitz obj. $\frac{1}{12}$.

FIG. 57. Embryo sac of *R. septentrionalis*, showing the one-sided enlargement of the sac, the lateral position of the antipodals, the parietal layer of endosperm nuclei, and a two-celled embryo.

FIG. 58. Embryo sac of *R. multifidus*, with egg and free endosperm nuclei.

FIG. 59. Two-celled embryo of *R. multifidus.*

FIG. 60. The same of *R. septentrionalis.*

FIGS. 61–64. Two to three-celled embryos of *R. septentrionalis.*

FIGS. 65. Three-celled embryo of *R. septentrionalis.*

FIG. 66. Four-celled embryo of the same.

FIG. 67. Four-celled embryo of *R. multifidus.*

FIGS. 68–72. Various stages in young embryos of *R. multifidus* (*fig.* 71 is from *R. septentrionalis*), involving the first longitudinal division.

FIG. 73. Young embryo of *R. multifidus*, showing a late transverse division of the basal cell.

OBSERVATIONS ON SOME WEST AMERICAN THERMAL ALGÆ.

JOSEPHINE E. TILDEN.

(WITH PLATES VIII–X)

It is the purpose of this paper to present an annotated list, with drawings, of thermal algæ, based on collections made in several western localities during the past two years.

Collection no. 1 was made by the writer in Yellowstone National Park during June and July of 1896. Specimens were preserved in formalin and a quantity of each kind was also dried. The natural color of the growths *in situ* was compared with the plates in Saccardo's *Chromotaxia*, ed. 2, 1894.

The hot waters of the Park are either calcareous, as at Mammoth Hot Springs, or contain silica in solution, as at Norris, Lower, Middle, and Upper Geyser Basins. Travertine results from the growth of algæ in calcareous waters, and siliceous sinter in siliceous waters.

Collection no. 2 was made by the writer from warm springs at Salt Lake City, Utah, in July 1897.

Collection no. 3 was made by the writer from the Natural Sulphur Spring at Banff, Alberta, during the month of August 1897. The warm springs of Banff are used for bathing purposes. They are situated on high ground and most of the overflow is carried away by means of ditches, several feet deep, which lead down the steep hillside. Here the water accumulates on a level space and forms a shallow but quite extensive pond or lake. Some of the overflow escapes underground for a short distance and appearing again halfway down the hill spreads out in terraces and finally joins the stagnant water below. These sheets of water have naturally lost much of their heat, but they are still tepid and support a luxuriant growth of Chara and other

Chlorophyceæ, numerous species of mosses, equisetum, etc. The water in the ditches is only a few inches in depth, but has a swift current. By the time it has reached the base of the hill it is but slightly warm. The older portions of the "formation" on this hillside are composed of travertine produced by mosses.

Collection no. 4 was made by Mr. Walter Harvey Weed in Yellowstone National Park during 1897, and sent to me for determination. This adds new localities and several new forms to the list.

Collection no. 5 was made by Professor Francis E. Lloyd from hot springs in the region of the Cascade mountains, Oregon.

OEDOGONIUM CRENULATO-COSTATUM Wittr. var. AUREUM Tild. Am. Alg. Cent. II. no. 123. 1896. (*Pl. VIII, figs. 1, 2, 3.*)

Oogonia single or 2–3-seriate, elliptical or oboviform, opening by a pore in upper portion; oosperms nearly filling the oogonia, exospore smooth, endospore crenulate-costate, reticulate, orange-colored (*aurantiacus*); supporting cell similar to the other vegetative cells; filament of male plant slightly smaller than that of female; antheridial cells alternating with vegetative cells, 2–5-celled; terminal cell (sometimes an oogonium) obtuse; vegetative cells 10–13 μ in diameter, 3.5–6 times longer; oogonia 32–37 × 40–50 μ; oosperms 29–30 × 38–39 μ; antheridial cells 10 × 10 μ. In overflow from small hillside spring. Water tepid. Between Middle and Upper Geyser Basins, Yellowstone National Park. J. E. T. 2 Jl 1896.

The endospore in this plant is crenulate-costate, but with transverse as well as longitudinal costae; the dimensions of the vegetative cell differ a little from those given in the type description; the mature oospores are bright orange-colored, a character not mentioned in the specific description; it occurs in thermal, flowing water, instead of cold stagnant water. In all other respects the variety is similar to the species.

An Oedogonium was also found in the tepid terrace waters at Banff, but as it was not in fruit the description is omitted. For a like reason a species of Zygnema growing with it is not described.

HORMISCIA FLACCIDA (Kg.) Lagerh. var. CALDARIA (Kg.) Hansg. Prodr. 61. 1886–1888 and in Flora 265. 1888. Tilden. Am. Alg. Cent. II. no. 130. 1896. (*Pl. VIII, figs. 4, 5.*)

Stratum dull green, soft, in long strings, dark green in the current, light green scum in the standing water; vegetative cells 5–7.5 μ wide, 0.5–2 times as long as the diameter.

In water from hot spring flowing down a grassy bank. Temperature 23° C. Norris Geyser Basin, Yellowstone National Park. J. E. T. 26 Je 1896.

This form seems to agree almost equally well with the above variety and with *H. subtilis* (Kg.) De Toni var. *thermarum* (Wartm.) Rabenh. Like the former, it occurs in soft somewhat lubricous masses. Its measurements correspond exactly, if the cells undergoing division be excepted. A filament made up entirely of mature cells would resemble Kützing's figure in *Tab. Phyc.* 3: *pl. 32, f. 3.* 1853. On the other hand, its habitat seems to accord better with the latter variety. When compared with Rabenhorst's Algen Sachs. no. 655 (placed here by De Toni) there is found to be no special difference in appearance. The diameter of Rabenhorst's specimen is slightly greater, perhaps, and the length of the cells, while in general 1–1.5 times the diameter, in many cases is twice the diameter. It would then appear that the Yellowstone plant agrees with the description of one species and an authentic specimen of another species as these are offered in De Toni's *Sylloge Algarum.* If forma *crassior* Hansg. of var. *thermarum* be taken into account, there would seem to be no objection to making a single variety of the two, especially as they belong to species so nearly related. In that case, according to the rule of priority, the plant would take the above name.

CONFERVA MAJOR (Kg.) Rabenh, forma **ferruginea**, n. f. (*Pl. VIII, figs. 6, 7, 8.*)

Brownish (*ferrugineus, fulvus*); filaments encrusted with ferric-oxide ($Fe_2 O_3$), sometimes in narrow bands, generally forming extensive coatings; cells 13–20 μ in diameter, twice the diameter in length, after division equaling the diameter.

In acid waters of overflow. Temperature 74° C. "These algæ are in part coated with Fe_2O_3 on the margins of the pools." Echirus Geyser. W. H. W. 1897.

The width of the filament in the form is somewhat narrower than that of the species. The specimen shows well the "letter H" appearance of the ruptured membrane which De Toni makes a generic character.

Conferva major (Kg.) Rabenh. forma **gypsophila,** n. f. (*Pl. VIII, figs. 9, 10, 11.*)

Forming white or yellowish masses; filaments encrusted with crystals of gypsum; cells 10–20 μ in diameter, twice as long as wide, after division equaling in length the diameter; cell contents granular, colorless; cell membrane thick.

Lying near vent of spring. Temperature 66° C. Norris Geyser Basin, Yellowstone National Park. J. E. T. 27 Je 1896.

This plant likewise differs from the species in having a narrower filament. Little spiny or lobed masses of gypsum, a centimeter in thickness, are found entwined with the threads.

Microspora amoena (Kg.) Rabenh. forma **thermalis,** n. f. (*Pl. VIII, fig. 12.*)

Dark green, stringy; cells cylindrical, 11–14 μ in diameter before division 2–3 times as long as wide, after division equal t or a little more than the diameter in length; membrane smooth delicate, firm; cell contents finely granular, bright green; filaments not constricted at septations.

(*a*) Lying in overflow from spring. Temperature 41° C Frying Pan Basin, Yellowstone National Park. J. E. T. 7 Jl 1896.

It is difficult to decide whether this plant should be classed as a Conferva or a Microspora, as the structure of the chloroplastids could not be made out. It is placed here provisionally. Its size is not as great as that of the species.

(*b*) A second gathering, slightly different in color, was vegetative green becoming yellowish. It occurred in soft masses on bottom of a spring. Temperature 38° C. Locality and date same as above.

In the first collection small prickly masses of mineral formation, probably gypsum, also occurred. *Chroococcus varius* was present in great quantity. The second collection contained Protococcus cells.

Microspora Weedii, n. sp. (*Pl. VIII, fig. 13.*)

Cespitose-floccose, dark green in denser parts, pale bluish-green in thinner portions; vegetative cells cylindrical, sometimes a little constricted at the septations, 7–9 μ in diameter, before division 0.5–3 times longer than diameter; membrane homogeneous, hyaline, thin.

(*a*) Bright green. Forms jelly on slope. Temperature 49° C. Growler, Norris Basin, Yellowstone National Park. W. H. W. 1897.

The peculiar bluish-green color is no doubt caused by the action of the formalin upon the plant, but it is worth noting since it has not been observed in other formalin material of the green algæ. The plant probably is nearest to *M. abbreviata* (Rabenh.) Lagerh. but differs from it in being entirely free from the ferruginous color, in having a thin membrane, and in its habitat.

RHIZOCLONIUM HIEROGLYPHICUM (Ag.) Kg. var. **atro-brunneum**, n. var. (*Pl. VIII, figs. 14, 15, 16, 17.*)

In long strings, dark brown (*fuligineus*); normal vegetative cells 15–22 μ in diameter, less than once as long to three times longer than wide, very variable in size in the same filament, rarely producing short rhizoids; cell contents (examined when fresh) dark brown, granular.

(*a*) In shallow water, plastered to surface of ground, most luxuriant in slow current. In overflow, through grass, of hot spring on bank above. Temperature 24° C. Norris Geyser Basin, Yellowstone National Park. J. E. T. 27 Je 1896.

(*b*) Dull brown filaments. In overflow channel. Temperature 38° C. Near Constant Geyser, Norris Geyser Basin, Yellowstone National Park. W. H. W. 1897.

Nearly every filament of my specimen contains one or more distorted cells. These are sometimes swollen to several times the size of the normal cells, and in general have a thicker wall. It was first thought that the plant might be identical with or at least related to *Hormiscia ? thermalis* Crouan (in Mazé and Schramm *Algues de la Guadeloupe* ed. 2, p. 42). But since access cannot be had to this specimen and the data furnished in the type description (De Toni *Sylloge Algarum* **1**: 171. 1889) is confined to a statement of the color and habitat—"Atro-brunnea. Hab. ad muros lateritios in aquario thermali (36° C) ad 'Dolé' insulae Guadeloupensis (Coll. n. 351. II série)"—it is thought best to place it under the above name.

Mr. Weed's specimen appears to be exactly the same plant. It shows, however, almost no trace of the distortion and no lateral projections could be found.

PROTOCOCCUS BOTRYOIDES (Kg.) Kirchn. forma **caldarius**, n. f. (*Pl. VIII, fig. 18.*)

Aquatic, vegetative or yellowish green; cells globose, 4–6μ in diameter, for the most part solitary; membrane thin, homogeneous, hyaline; cell contents homogeneous, vegetative green.

(*a*) On bottom of spring. Temperature 38° C. With *Microspora amoena*, forma *thermalis*. Frying Pan Basin, Yellowstone National Park. J. E. T. 7 Jl 1896. Agrees with species with exception of habitat.

CALOTHRIX THERMALIS (Schwabe) Hansg. Beiträge zur Kenntniss der Böhmisch. Thermalalgenflora (Oesterr. Bot. Zeitschrift **34**: 279. 1884. (*Pl. IX, figs. 1, 2, 3, 4, 5.*)

Stratum soft, dark seal brown or black; filaments crowded, flexuose, 10–13μ, rarely 18μ in diameter, thickened at base; sheath in young plants thick, lamellated, colorless, in older plants wider, brownish; trichome in young plants 5–9μ in diameter, bright blue-green, granular, distinctly articulated or rarely with dissepiments not visible, sometimes moniliform, in older plants paler aeruginous, much narrower, with shorter articulations, not plainly visible, with apex tapering to a hair-point; articulations equal in length to diameter, but often, particularly in younger plants, twice the diameter in length; heterocysts 1–2 seriate, basal or intercalary, very variable in size and shape.

(*a*) Overflow of channel of geyser. Temperature 49–54.5° C. Spasmodic Geyser, Upper Geyser Basin, Yellowstone National Park. W. H. W. 1897.

(*b*) Forming cedar-colored fur on overflow channel of geyser. Old Faithful Geyser, Upper Geyser Basin, Yellowstone National Park. W. H. W. 1897.

(*c*) With other algæ in rivulets. Temperature 49–50° C. Fountain Hotel Geyser Basin, Yellowstone National Park. J. E. T. 29 Je 1896.

(*d*) Very common in colder portions of overflows. Varying in color from *umbrinus* to *castaneus* and *fuligineus*. Growing in small islands or forming smooth surfaces. Temperature 34° C. Emerald Pool, Upper Geyser Basin, Yellowstone National Park. J. E. T. 3 Jl 1896.

Mr. Weed has frequently mentioned this plant, but under other names. He describes an algal sinter which, "forming in the overflow channels of many of the geysers of the Upper Basin, is finely fibrous, consisting of layers one-sixteenth of an inch to half an inch thick, each stratum resembling a very fine thick white fur. This sinter is formed by the growth of the little algæ, *Calothrix gypsophila* Kg., or the young form, *Mastigonema thermale*, the latter olive-colored."[1] Again, "the proportion of algal sinter forming the deposits about the Geyser Basins is strikingly shown in the following section of the strata forming the wall of Excelsior crater. . . . In this section 50 per cent. consists of the fibrous sinter formed by

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[1] Formation of travertine and siliceous sinter by the vegetation of hot springs. U. S. Geol. Surv. 9th Ann. Rep., 665. 1889.

Mastigonema."[2] He describes a specimen of New Zealand sinter from the hot waters of Rotorua, and notes that "the exact counterpart of this sinter occurs at many localities in the geyser basins of the Yellowstone, notably about the Prismatic Spring and the overflow channels of Old Faithful. It forms over one-half of the section of fifteen feet of sinter exposed in the crater walls of the Excelsior Geyser. This sinter we know to be the result of the growth and incrustation of little algæ, which form a cedar-colored (*Calothrix gypsophila* Kg.), or olive (*Mastigonema thermale*) slippery coating on the surface of the deposit. The analogy is so perfect that there seems but little doubt that the New Zealand sinter is the result of the growth of similar or allied algæ."[3]

The plant *Calothrix gypsophila* (*Dichothrix gypsophila*) is a lime-encrusting form. I have not personally observed it up to this time in material from Yellowstone Park. *Mastigonema thermale*, a synonym of *Calothrix thermalis*, does not characteristically secrete lime. The Yellowstone form has only been found in siliceous waters. It differs slightly from the type description of Bornet and Flahault in that the articulations, instead of being "diametro æqualibus vel usque ad 3-plo brevioribus" are equal to up to three times *longer* than the diameter. It agrees, however, in this character with Hauck and Richter's specimen in *Phyk. univ.* no. 742, which was collected from the Carlsbad springs in 1894 and 1895 by S. Schmula. Therefore the two forms named by Mr. Weed are considered to be the same plant.

The above species has been described from Carlsbad, Germany, by Schwabe, Kützing, and Cohn.

RIVULARIA HAEMATITES (DC.) Ag. Syst. Alg. 26. 1824. (*Pl. IX, figs. 6, 7, 8, 9.*)

Thallus forming a hard calcareous crust, 5^{mm} in thickness; filaments dense, 7.8–11.7μ in diameter; sheath narrow, hyaline, rarely brownish; trichomes 3.9–5.2μ in diameter, with lower cells one to two times longer than wide, middle cells two to three times longer than wide, and upper cells in general subquadrate, with apex prolonged into a thread; cell contents granular.

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[2] Loc. cit.

[3] Loc. cit. 674.

Forming a calcareous crust on bottom of ditch. Natural Sulphur Springs, Banff, Canada. J. E. T. 13 Ag 1897.

This growth occurs toward the lower end of the ditch where the water is slightly warm and the current very swift. The general appearance and microscopic characters agree very well with authentic specimens in the Minnesota herbarium.

HAPALOSIPHON MAJOR Tild. Am. Alg. Cent. II. no. 167. 1896. (*Pl. IX, figs. 10, 11, 12, 13.*)

Stratum widely expanded, bright aeruginous in color; filaments sheathed, branched, composed of cells sometimes cylindrical, 3–6μ in width, showing no dissepiments, or divided into short somewhat quadrate to very long cells, sometimes globose up to 11μ in diameter; branches single or geminate, sometimes geniculate; heterocysts intercalated, oblong, cask-shaped, about 8μ in width, one to two times as long as wide.

(*a*) Completely coating bed of very swift mountain rivulet, at vent of hot spring. Temperature of spring 61° C. Algal growth begins here and disappears at a distance of fifty-five feet from spring where temperature is 51° C. Most luxuriant growth thirty-five feet from spring at temperature of 54° C. Mountains near Lower Geyser Basin, Yellowstone National Park. J. E. T. 28 Je 1896.

(*b*) In hot spring. Temperature 55° C. Cascade mountains, lat. 45° 20′. Francis E. Lloyd, 1895.

The filaments of *H. major* are nearly twice the diameter of those of *H. laminosus*. An important character of the latter plant is its habit of forming crystals of lime, according to Cohn, who studied the plant at Carlsbad. The Yellowstone species occurred in siliceous waters only, at least it was not discovered at Mammoth Hot Springs, where the waters contain calcium carbonate.

Schizothrix calcicola (Ag.) Gomont, Monographie des Oscillariées, Ann. Sci. Nat. (Bot.) VII. **15**: 307. *pl. 8, figs. 1-3.* 1892. Tilden, Am. Alg. Cent. II. no. 180. 1896. Described in Bot. Gaz. **24**: 197, 198. *pl. 8, figs. 3, 4.* 1897.

Symploca thermalis (Kg.) Gomont. Monogr. des Oscill. in Ann. Sci. Nat. (Bot.) VII. **16**: 114. *pl. 2, figs. 15, 16.* 1892. (*Pl. IX, fig. 14.*)

Stratum dark aeruginous, widely expanded; filaments very rarely pseudo-branched, fragile, densely intricate, crisp; sheath thin; trichomes pale aeruginous, not attenuate at the apex, 1.5-2 μ in diameter; articulations two to three times longer than the diameter of the trichome, rarely somewhat quadrate, 2-5 μ in length; protoplasm homogeneous, rarely containing granules; dissepiments visible; apical cell rotund; no calyptra.

(*a*) Forming extensive layers or knob-like masses on bottom of ditch. Natural Sulphur Springs, Banff, Canada. J. E. T. 13 Ag 1897.

The appearance of this growth was peculiar. The rich blue-green surface of the layer was marked off into broad ridges of a lighter color, making it resemble very much the ripple-marks left in sand by waves. The filaments are nearly prostrate, taking the direction of the current. It occurred in the same ditch with *Rivularia haematites*, but farther up the hill. The water here is warmer and the current not quite so swift.

Phormidium laminosum (Ag.) Gomont. Essai de Class. des Nostocacées homocystées in Morot, Journ. de Bot. **4**: 355. 1890. Tilden, Am. Alg. Cent. II. no. 181. 1896. (*Pl. IX, fig. 15.*)

Stratum mucilaginous, yellowish, bluish, or bright green, or forming a scurfy, thin, brittle scum with a soft gelatinous cushion underneath; filaments flexuous, densely intricate; sheath not visible; trichomes pale aeruginous, not constricted at joints, with apex straight, briefly attenuate and not capitate, 1.6μ in diameter; articulations longer than the diameter of the trichome.

2.5–3.2μ in length; dissepiments marked by granules; apical cell acutely conical; no calyptra.

(*a*) In overflow water of spring where the old formation makes a hard, billowy or terraced incline, the algæ extend down the incline for a distance of twenty feet, forming wide ribbons of green alternating with bands of pink, yellow, white, and a darker green. Temperature of spring 91° C. The algal growth occurs at a temperature of 51–55° C. Ribbon Spring, Norris Geyser Basin, Yellowstone National Park. J. E. T. 27 Je 1896.

(*b*) In small shallow spring, expanding at top in leaf-like masses, or tapering from bulbous head to a small tubular base. Temperature 55° C. Valley of Nez Perces creek, Lower Geyser Basin, Yellowstone National Park. J. E. T. 28 Je 1896.

(*c*) In grassy rivulet. Temperature 30° C. Mountain hot springs, Lower Geyser Basin, Yellowstone National Park. J. E. T. 28 Je 1896.

(*d*) Around edges of springs. Forming brown and green layers which turn gray or blackish out of the water. Temperature 63° C. Prismatic Lake, Middle Geyser Basin, Yellowstone National Park. J. E. T. 2 Jl 1896.

(*e*) Forming plumy strings, white or light yellowish in color. Temperature 75.5° C. Solitary Spring, Upper Geyser Basin, Yellowstone National Park. J. E. T. 3 Jl 1896.

(*f*) Forming whitish, scurfy, hardened, rather brittle scum on surface of still pool into which overflow runs. Temperature 41° C. Mammoth Hot Springs, Yellowstone National Park. J. E. T. 8 Jl 1896.

I found this species to be by far the most widespread and abundant of any alga in the hot waters of the park. Its habit of growth is extremely varied, so that it is not easily recognized. It is the only species, except *Spirulina major*, that, so far as I know, is found in both calcareous and siliceous waters in this region.

PHORMIDIUM LAMINOSUM (Ag.) Gomont, forma **Weedii,** n. f. (*Pl. IX, fig. 16.*)

Stratum aeruginous; filaments often strongly bent; sheath not visible; trichomes pale aeruginous, not constricted at joints with apex sharply bent, briefly attenuate and not capitate, 2.5–3μ in diameter, the dissepiments generally distinct; articulations 1.5–2.5 times as long as the diameter; protoplasm commonly containing granules; dissepiments sometimes marked by granules; apical cell acutely conical; no calyptra.

(*a*) In overflow of channel. Temperature 49–54.5° C. With *Spirulina major*. Spasmodic Geyser, Upper Geyser Basin, Yellowstone National Park. W. H. W., 1897.

This plant is very near typical *P. laminosum*. The points of difference are that the filaments are slightly greater in diameter, the apex is almost invariably sharply bent and the dissepiments may or may not be marked by granules. Sometimes the entire cell contents are granular.

PHORMIDIUM TENUE (Menegh.) Gomont. Monogr. des Oscill. in Ann. des Sci. Nat. (Bot.) VII. **16**: 169. *pl. 4, f. 23–25.* 1892. Tilden, Am. Alg. Cent. II. no. 182. 1896. (*Pl. IX, fig. 17.*)

Stratum consisting of a thick firm mass, 10–40^{mm} in thickness, upper exposed surface honeycombed, the ridges being thin and papery, and easily crushed; in color surface showed a range between *ferrugineus* and *ochraceus*, the interior between *viridis* and *prasinus;* filaments very long, somewhat straight; sheath delicate; trichomes light aeruginous, straight, constricted at joints, the dissepiments themselves generally indistinct, with apex straight or sometimes bent, not capitate, 2–3μ in diameter, articulations in general 1.5–2 times the diameter, 3–6.4μ in length; protoplasm homogeneous; apical cell acutely conical or bluntly rounded; no calyptra.

Around edges of spring, not covered by water, but water flows in little streams through and around it. Temperature of water 33°C. Lower Geyser Basin, Yellowstone National Park. J. E. T. 29 Je 1896.

PHORMIDIUM RUBRUM Tilden, Am. Alg. Cent. II. no. 18 1896. (*Pl. IX, fig. 18.*)

Stratum thin, scarlet (*miniatus*); filaments somewhat straight; sheath visible under high powers; trichomes fragile, frequently interrupted, neither attenuate nor curved, not constricted at joints, 1μ in diameter; articulations quadrate or a little longer than broad; dissepiments not or rarely visible.

In overflow from small hillside spring. Water tepid. Between Middle and Upper Geyser Basins, Yellowstone National Park. J. E. T. 2 Jl 1896.

This species is near *P. luridum* and *P. purpurascens*. From the former it differs in not having trichomes constricted at joints. From the latter it differs in not having strongly tortuous filaments nor granulated dissepiments. It is also to be distinguished from both by the color of the stratum and of the trichomes and the length of the articulations.

Oscillatoria princeps Vauch. Hist. Conferv. d'eau douce 190. *pl. 15, f. 2.* 1803. Tilden, Am. Alg. Cent. II. no. 187. 1896. (*Pl. IX, fig. 19.*)

Stratum dark green or black; trichomes 16–19μ in diameter; apex slightly attenuate and shortly arcuate; articulations 4.5–5.5μ long; protoplasm finely granulate; apical cell convex; calyptra none.

(*a*) Forming a black thick floating mass in mountain stream at vent of hot spring; gradually running out, and replaced by green at a distance of fifty feet from vent. Temperature five feet from spring 42°C., fifty feet from spring 38°C. Mountains near Nez Perces creek, Lower Geyser Basin, Yellowstone National Park. J. E. T. 28 Je 1896.

(*b*) Forming dark green velvety mass fringing edge of small mountain creek where a hot spring flows out just underneath the bank. Temperature of water one inch below surface 19°C. On surface 58° C. Near Emerald Pool, Upper Geyser Basin, Yellowstone National Park. J. E. T. 3 Jl 1896.

Oscillatoria tenuis Ag. Alg. Dec. 2:25. 1813. Tilden, Am. Alg. Cent. II. no. 190. 1896. (*Pl. IX, fig. 20.*)

Stratum black or purplish (*atro-violaceus*); filaments dilute purplish-black (*atro-cyaneus*), straight or somewhat flexuous constricted at the dissepiments, for the most part 8–13μ in diameter, not attenuate at apex, straight or but slightly arcuate at extremities; articulation 0.25–0.5 times as long as wide, 3–4 long; protoplasm homogeneous; dissepiments sometimes granulose; apical cell conical, not capitate; no calyptra.

In small mountain spring in a bog, together with moss and watercress. Water tepid. Valley of Nez Perces creek, Lower Geyser Basin, Yellowstone National Park. J. E. T. 28 Je 189

Oscillatoria amphibia Ag. Aufzählung, etc. in Flora 10: 632. 1827. (*Pl. IX, fig. 21.*)

Stratum aeruginous, red or orange colored; trichomes dilute aeruginous, straight or arcuate, fragile, not constricted at dissepiments, 1.5–2μ in diameter, arcuate for some distance at extremities, apex neither attenuate nor capitate; articulations two to three times longer than diameter of trichome, 3–4μ in length dissepiments sometimes marked by two protoplasmic granules sometimes not distinct; cell contents granular; apical cell rotund

Forming lining in channel of spring. Above Beehive Geyser, Upper Geyser Basin, Yellowstone National Park. W. H. W. 1897.

The red and orange colors in this material are caused by the presence of bacteria.

Oscillatoria geminata Menegh. Conspect. Algol. euganeae 9. 1837. Tilden, Am. Alg. Cent. II. no. 191. 1896. (*Pl. IX fig. 22.*)

Stratum dark green, forming long plumy tufts; trichomes pale aeruginous, densely interwoven, very much constricted at joints, 3.2μ thick; apex straight, not attenuate nor capitate articulations of unequal length, quadrate or longer than the diameter, 3.2–7μ long; protoplasm containing granules; dissepiments pellucid, not granulated; apical cell rotund; no calyptra.

Covering bottom of creek in swift current. Temperature

47.5°C. Near Upper Geyser Basin, Yellowstone National Park. J. E. T. 2 Jl 1896.

SPIRULINA MAJOR (Kg.) Phyc. Gener. 183. 1843. Tilden, Am. Alg. Cent, II. no. 193. 1896. (*Pl. VIII, fig. 19.*)

Forming a thin brittle scurfy scum, whitish on top; stratum dull green (*prasinus*); trichomes pale green, wound into somewhat straight, dense, very regular spirals with a diameter equaling 3μ, in thickness 1μ; turns contiguous.

(*a*) On surface of still pool into which overflow runs. Temperature 41°C. Mammoth Hot Springs, Yellowstone National Park. J. E. T. 8 Jl 1896,

(*b*) Overflow of channel of geyser. Temperature 49–54.5°C. Spasmodic Geyser, Upper Geyser Basin, Yellowstone National Park. W. H. W. 1897.

(*c*) Forming a whitish brittle scum in the hot water. Beck's Hot Springs. Salt Lake City, Utah. J. E. T. 7 Jl 1897.

This species is quite common in both the calcareous and siliceous waters of the Park. It is generally found with other algæ. I did not find any pure growths.

Spirulina caldaria, n. sp. (*Pl. VIII, fig. 20.*)

Stratum widely expanded, dark aeruginous; trichomes aeruginous, short, somewhat straight and stiff, forming a very lax spiral with a diameter of 1.5μ, 0.9μ in thickness; turns 3.2μ distant from each other.

(*a*) Forming thick richly colored strata on surface of hot water very near outlet of the springs. Natural Sulphur Springs, Banff, Canada. J. E. T. 13 Ag 1897.

SYNECHOCOCCUS ÆRUGINOSUS Næg. Einz. Alg. 56. 1849. Tilden. Am. Alg. Cent. II. no. 195. 1896. Described in BOT. GAZ. **24**: 198. *pl. 8. fig. 6.* S. 1897.

GLŒOCAPSA VIOLACEA (Corda) Rabenh. Fl. Eur. Algar. **2**: 41. 1865. Tilden. Am. Alg. Cent. II. no. 196. 1896. Described in BOT. GAZ. **24**: 198. *pl. 8. fig. 5.* S. 1897.

Chroococcus varius A. Br. Rabenh. Alg. Eur. no. 2451 a 2452. Tilden. Am. Alg. Cent. II. no. 198. 1896. (*Pl. VII fig. 21.*)

Cells spherical, single or in small groups, 1.6–5.6 μ in diameter; cytoplasm pale aeruginous.

(*a*) On rocks. Near vent of geyser. Sometimes heated. Norris Geyser Basin. Yellowstone National Park. J. E. T. Je 1896.

(*b*) With *Microspora amœna* var. *thermalis*, lying in overflow from spring. Temperature 41° C. Frying Pan Basin. Yellowstone National Park. J. E. T. 7 Jl 1896.

(*c*) Forming a green coating on floor of overflow channel. Temperature 49° C. Constant Geyser, Norris Geyser Basin. Yellowstone National Park. W. H. W. 1897.

(*d*) In acid waters. Green Spring. Between Norris Geyser Basin and Beaver Lake. Yellowstone National Park. W. H. W 1897.

University of Minnesota.

EXPLANATION OF PLATES VIII–X.

PLATE VIII.

Fig. 1. *Œdogonium crenulato-costatum* Wittr. var. *aureum*. Filament of female plant showing twin oogonia containing oosperms.

Fig. 2. Filament of male plant with five antheridial cells.

Fig. 3. Apical cell of filament.

Figs. 4, 5. *Hormiscia flaccida* (Kg.) Lagerh. var. *caldaria*. Filaments with cells of different lengths.

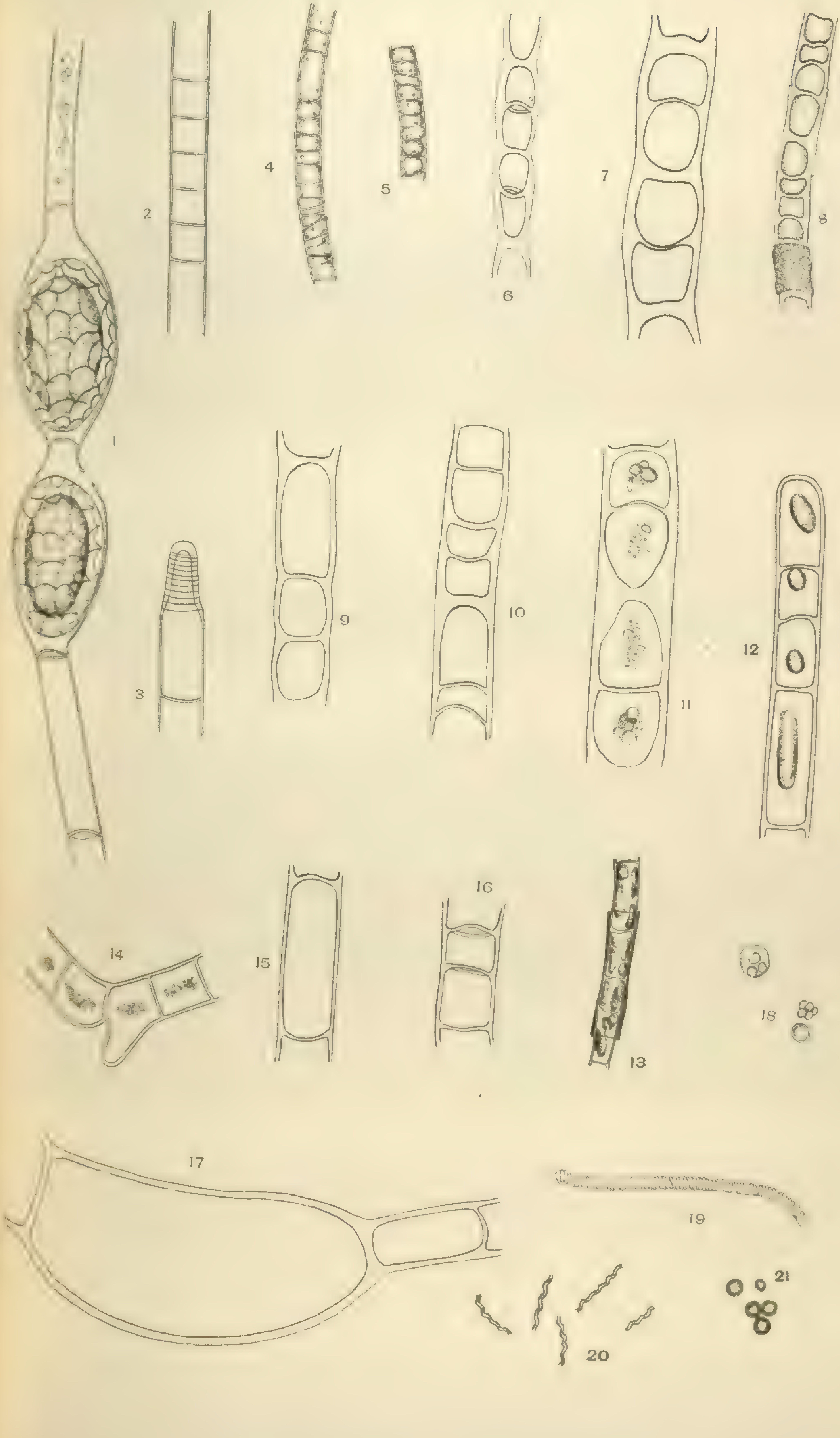
Figs. 6, 7. *Conferva major* (Kg.) Rabenh. forma *ferruginea*. Filaments of empty cells showing relative thickness of old and new walls.

Fig. 8. Filament of same showing cell contents, incrustation of Fe$_2$ and characteristic appearance of ruptured sheath.

Figs. 9, 10, 11. *Conferva major* (Kg.) Rabenh. forma *gypsophila*. Filaments giving characteristic appearance of cell wall and cells of different lengths.

Fig. 12. *Microspora amœna* (Kg.) Rabenh. forma *thermalis*. Extremi of filament.

Fig. 13. *Microspora weedii*. Filament showing cell contents and sheath forming "letter H."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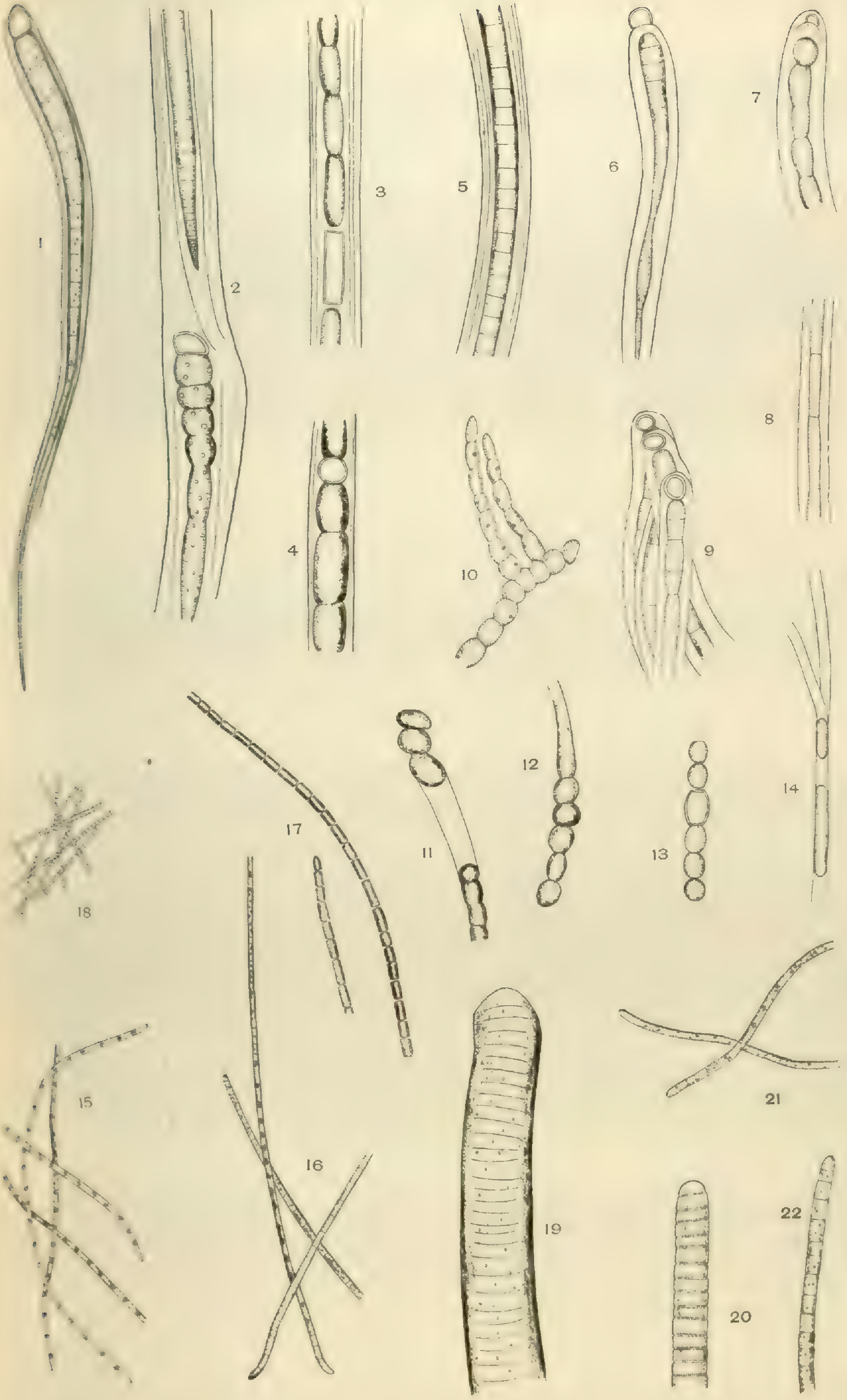
TILDEN on THERMAL ALGÆ.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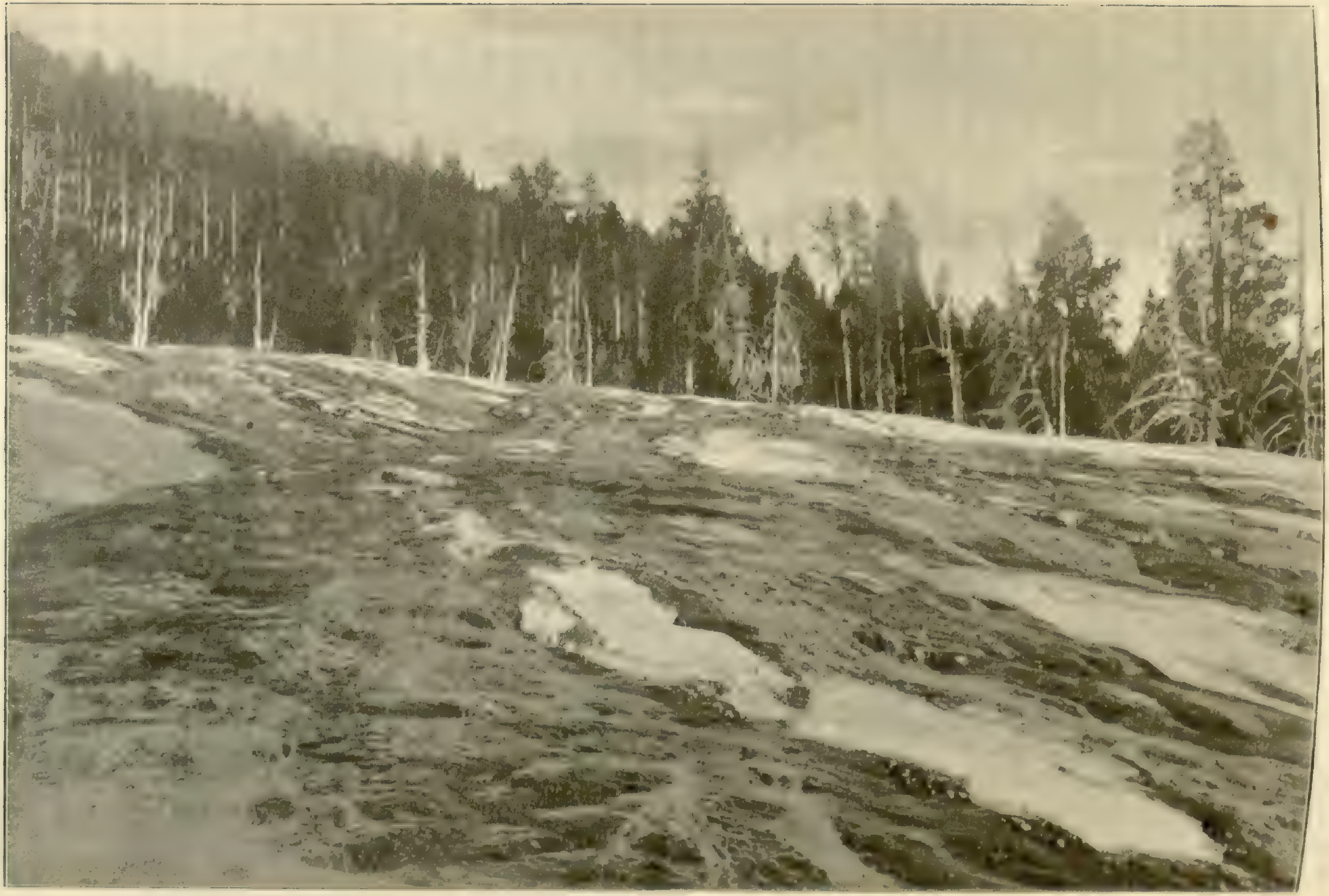

TILDEN on THERMAL ALGÆ.

FIG. 14. *Rhizoclonium hieroglyphicum* (Ag.) Kg. var. *atro-brunneum*. Filament showing lateral process and disposition of cell contents.

FIGS. 15, 16. Portions of filaments showing appearance of normal cells.

FIG. 17. Portion of filament showing a distorted cell.

FIG. 18. *Protococcus botryoides* (Kg.) Kirchn. forma *caldarius*. Appearance of cells in process of division.

FIG. 19. *Spirulina major* Kg. Portion of filament.

FIG. 20. *Spirulina caldaria*. Portions of filaments.

FIG. 21. *Chroococcus varius* A. Br. General appearance of cells.

PLATE IX.

FIG. 1. *Calothrix thermalis* (Schwabe) Hansg. Young plant entire, showing basal heterocyst and trichome indistinctly septate.

FIG. 2. Portion of mature filament with branch. The trichome of branch shows well the moniliform character and granular protoplasmic contents.

FIG. 3. Portion of filament with oblong intercalary heterocyst.

FIG. 4. Portion of filament with spherical intercalary heterocyst.

FIG. 5. Portion of filament with articulations as long as wide.

FIG. 6. *Rivularia hæmatites* (DC.) Ag. Young plant.

FIGS. 7, 8. Mature forms showing moniliform and cylindrical trichomes.

FIG. 9. Branching filament.

FIG. 10. *Hapalosiphon major* Tild. Filament with twin branches.

FIG. 11. Filament showing empty sheath.

FIG. 12. Filament showing both moniliform and cylindrical trichome.

FIG. 13. Filament with heterocyst.

FIG. 14. *Symploca thermalis* (Kg.) Gomont. Filament with pseudo-branch.

FIG. 15. *Phormidium laminosum* (Ag.) Gomont. Filaments.

FIG. 16. *Phormidium laminosum* forma *Weedii*. Filaments.

FIG. 17. *Phormidium tenue* (Menegh.) Gomont. Filaments.

FIG. 18. *Phormidium rubrum* Tilden. Filaments.

FIG. 19. *Oscillatoria princeps* Vauch. Apex of filament.

FIG. 20. *Oscillatoria tenuis* Ag. Apex of filament.

FIG. 21. *Oscillatoria amphibia* Ag. Portions of filaments.

FIG. 22. *Oscillatoria geminata* Menegh. Apical end of filament.

PLATE X.

A photograph of Solitary Spring, Upper Geyser Basin, Yellowstone National Park. *Phormidium laminosum* forms a part of the algal growth of this spring.

SOCIETY FOR PLANT MORPHOLOGY AND PHYSIOLOGY.

ITHACA MEETING, DECEMBER 28–29, 1897.[1]

THE first meeting of the new Society for Plant Morpholo and Physiology was held in conjunction with the meetings the American Society of Naturalists and the affiliated societ at Cornell University, December 28 and 29, 1897. An acco of the formation and personnel of this society is given elsewh in this number. The following papers were presented :

1. *A mycorhiza in the roots of the liliaceous genus Philesia* : D J. M. MACFARLANE, University of Pennsylvania.— The auth stated that this was the second recorded case of symbio between a liliaceous plant and a fungus. The genus Phile grows in the damp humus soil of west Patagonia, and for coralloid root masses. The fungus was sparingly present side the roots, also in the epidermis and exocortex, but form an abundant growth in the mesocortex, the cells of wh rapidly became filled with coiled fungoid hyphæ. The lar spherical starch grains of these cells were acted on by hyphæ, and were dissolved by solution rather than by corros action. A large amount of proteid material then appeared the hyphæ. With growth of the root extremity, the fung steadily penetrated the mesocortex cells of the growing po numerous hyphæ being observed in the 10th–12th zone of c behind the apex. Invariably the crystal cells were untouched.

The close similarity of the above to cases recorded Groom for Thismia, and by other authors, was referred to the conclusion was reached that while the fungus might for many generations aid the host in the elaboration of protein compounds that were absorbed by the latter, ultimately, though very gradually, the fungus proved a destructive agent.

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[1] This report is furnished by the Secretary, Professor W. F. Ganong, Northamp Mass. The abstracts are in all cases by the authors.

2. *Studies on some mycelium and fungi from a coal mine :* PROFESSOR GEO. F. ATKINSON, Cornell University.— On the 14th of September the speaker explored abandoned portions of the Algonquin coal mine near Wilkesbarre, Pa., for the purpose of studying the mycelium formations on the doors in the gangways, and on the wood props which are used to support weak places in the roof above. Several flash-light photographs were made of the remarkable displays of the mycelium some four hundred feet below the surface, and of some of the fruit forms. Mature fruit collected has been determined as follows : *Polyporus versicolor, P. annosus, Coprinus micaceus, Stropharia, Hymenochæte, Merulius*, etc. The paper was illustrated with lantern views.

3. *Is there a basidiomycetous stage in the life-history of some Ascomycetes ?:* DR. E. A. BURT, Middlebury College.— Mr. Burt has been studying a case of undoubted association of *Graphium giganteum* (Pk.), otherwise known as *Dacryopsis Ellisiana* (Berk.) Massee, with the ascomycete *Lecanidion leptospermum* (Pk.), also known as *Holwaya tiliacea* E. & E. *Dacryopsis Ellisiana* was described and figured by Massee as a tremelloid basidiomycete. Mr. Burt has been unable, by the study of collections made in the months of August, October, November, and December, to confirm Massee's observations on the basidiomycetous nature of *Dacryopsis Ellisiana*, and therefore is unable to conclude, for the present, that it is a basidiomycetous stage of the ascomycete *Lecanidion leptosperma.*

4. *Additional notes on the bacterial brown rot of cabbages:* DR. ERWIN F. SMITH, Department of Agriculture.— Field studies of this disease were made in Michigan, Wisconsin, Ohio, and New York in August, September, and October of 1897. These served

to confirm the earlier published statements of the writer[2] respecting the manner of infection and the usual symptoms. A number of new facts which appear to have an important economic bearing were also brought to light. Some of these discoveries are as follows: (1) this disease is serious in many parts of the United States; (2) the greater part of the infections take place through natural openings of the plant, *i. e.*, through water pores located on the serratures of the leaves; (3) the disease is frequently disseminated by insects; (4) the wild mustard, *Brassica sinapistrum*, is one of the common host plants; (5) the disease is very frequently disseminated by man, *i. e.*, by making seed beds on infected soil and transplanting the germs in infected seedlings to land previously free from it; (6) when a soil has once become infected there is reason to believe that the germs are capable of living in it for a series of years and will attack cabbages which are planted on it; (7) the disease may be restricted by planting seed beds on healthy soil; by transplanting, as far as possible, to sod land, or at least to land not previously occupied by crucifers; by destroying wild mustards and parasitic insects; by removing badly affected plants bodily; and in early stages of the disease, *i. e.*, when the disease has only recently passed out of the water pore stage of infection, by removing affected leaves. A full account of the economic aspects of the disease has been published by the Department of Agriculture in the shape of a farmer's bulletin, which may be had on application. Cultures of the parasitic and dried leaves and stems of cabbage showing the characteristic symptoms were passed around.

5. *Occurrence of Kramer's bacterial disease on sugar beets in the United States*: DR. ERWIN F. SMITH, Department of Agriculture. —Attention was called to the existence in parts of the United States (Michigan, Wisconsin, etc.) of a disease of sugar beets much resembling if not identical with that described by Kramer and Sorauer in 1891–2, and more recently by Busse.[3] This

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[2] Science 5: 963. 1897; Centralb. f. Bakt. 3^2: 284. 1897.

[3] Zeitschr. f. Pflanzenkr. 7: 65.

root shrivels in places, becomes very black, and finally breaks down here and there, with the formation of a sticky exudate composed of bacteria. Cultures from the interior of blackened roots remained sterile. Cultures from the syrupy exudate yielded an organism resembling, so far as tested, that described by Busse as the cause of the disease. It is yet too early, however, to say whether the organism isolated is identical with *Bacillus betae* Busse, or whether it is in any sense a true parasite. It appears worth mentioning, inasmuch as it seems to be rather common, and destroys cane sugar, and grape sugar, with the formation of hydrogen, carbon dioxide, and an acid. Possibly this is one of the organisms which has given trouble to the chemists in sugar diffusion work, inverting the cane sugar and liberating gases.[4] Cultures on steamed and raw beets, on steamed potato, and in fermentation tubes were exhibited. On steamed slices of sugar beet there is a copious production of gas.

6. *Are blepharoplasts distinct from centrosomes?:* MR. HERBERT J. WEBBER, Department of Agriculture.—Blepharoplasts, the speaker pointed out, are special organs of the spermatic cells of Zamia, Ginkgo, and some Filicineæ and Equisetineæ, which in certain stages of their development somewhat resemble centrosomes. Two are formed in each generative cell, arising *de novo* in the cytoplasm on opposite sides of the nucleus, and about midway between the nuclear membrane and cell wall. The division of the generative cell results in the formation of two antherozoids, one blepharoplast being located in each antherozoid cell. During this division the blepharoplasts burst and the outer membrane becomes gradually extended into a narrow helicoid spiral band from which the motile cilia of the antherozoid are developed.

The blepharoplasts resemble typical centrosomes: (1) in position, being located on the opposite sides of the nucleus, and (2) in having the kinoplasmic filaments focused upon them during the prophases of the division of the generative cell. They differ from typical centrosomes, however, (1) in arising *de novo* in the cytoplasm; (2) in growing to comparatively enormous size; (3) in not forming the center of an aster at the pole of the spindle during mitosis; (4) in having a differentiated external membrane and contents; (5) in bursting and growing into a greatly extended cilia-bearing band, the formation of which is evidently their primary function; (6) in their non-continuity from cell to cell.

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[4] See Jour. Soc. Chem. Ind. 14:876.

7. *Spore formation in some sporangia:* DR. R. A. HARPER, Lake Forest University.—DR. Harper's paper is to be published with some additional material in the near future.

8. *Two new organs of the plant cell:* MR. WALTER T. SWINGLE, Department of Agriculture.—The author announced the finding of two new organs or organoids, the one *vibrioid*, occurring abundantly in the superficial layers of the cytoplasm of some Saprolegniaceæ and some Florideæ; the other being a central body in the developing egg of *Albugo candidus*. The vibrioids are slender cylindric sharply delimited bodies, about the size of many common bacilli, but exhibiting rather slow bending or undulatory proper motions in addition to translatory movements which are probably passive and due to the streaming of the cytoplasm in which they are imbedded. They are fixed well by ordinary killing agents, and when stained are very sharply differentiated from the surrounding cytoplasm. They can also be seen in the living cell. Their appearance suggests that they may be minute endo-parasites, but their constant occurrence in plants in all stages of development and from widely separated localities militates against this view. Their function in unknown.

The other new organoid is a nearly spherical body located at one end of the egg nucleus of *Albugo candidus*. It is often a little flattened on the side adjoining the nucleus, is not very sharply delimited from the cytoplasm, but stains differentially. It seems to be more or less granular in structure, appears just before delimitation of the egg within the oogonium, and disappears after fusion of the male and female nuclei. It probably plays some part in these two phenomena.

Both of the organoids have been observed before, but were not correctly described by previous writers.

9. *Notes on the archesporium and nucleus of Bignonia:* MR. B. M. DUGGAR, Cornell University.—The mature archesporium of the microsporangia occupies a single boot shaped layer. The primitive archesporium is differentiated by periclinal divisions in certain regions of the outer layer of periblem. The tapetum on the outer side is cut off by the next periclinal divison of the hypodermal layer, and the next division of the latter gives rise to the layer often becoming the fibrillar endothecium of anthers, but in Bignonia there is no fibrillar development. In general, there are no further periclinal divisions in the regions mentioned. The definitive archesporium is formed by not more than a single division in some or all of the primitive archesporial cells. The macrosporic archesporium apparently develops no primary tapetum, divides simultaneously from the two-celled stage, the third or fourth cell becoming the definitive embryo-sac mother cell. The archesporial nucleus, especially, is peculiar in the large nucleolar-like structure which does not stain homogeneously, the outer portion usually taking the violet in the Flemming combination.

10. *Some theories of heredity and of the origin of species considered in relation to the phenomena of hybridization:* MR. WALTER T. SWINGLE, Department of Agriculture.—Owing to limited time the speaker treated only the first portion of his theme, viz., the bearing of the facts of hybridization on some theories of heredity. It was pointed out that Weismann's theory of reduction of chromosomes, though giving a plausible explanation of the differences observed between the first (uniform) and second (polymorphic) generations of most hybrids, is not only in disaccord with the observed phenomena of spore and pollen formation in

higher plants, but fails to account for the extreme polymorphism often observed in the first generation of hybrids between races of cultivated plants, or between closely related species, as for example some racial hybrids of maize and some specific hybrids of Lychnis and Digitalis. Mr. Swingle considered it necessary to assume in some such cases, at least, a predetermination of the characters of the hybrid at the time of fusion of the male and female nuclei. The male and female chromosomes probably persist side by side unchanged in number, and possibly unchanged in quality during the whole of the ontogeny of the hybrid, reduction not occurring until the close of the first generation. It is therefore necessary to assume, in order to explain the observed fact of divergence of character in the first generation of some hybrids, that the influence exerted during ontogeny of the hybrid by the material bearers of heredity is, at least in some cases, a function of their relative positions; and further that in most cases the relative positions of these bearers of heredity, as determined at the moment of fusion of the male and female nuclei persist unchanged throughout ontogeny of the offspring. Some phenomena, such as reversions to the one or the other parent form by a larger or smaller portion of the hybrid, would be explained by assuming some change in the disposition of the hereditary substance, whereby they assumed a new position of partial or complete stability. The suggestion was made that possibly the difference between uniform and polymorphic hybrids of the first generation is due to a more complete intermingling of the hereditary particles in case of polymorphic hybrids (offspring of closely related organisms), whereby many differing combinations would be possible, and in case of uniform hybrids (mostly offspring of distinct species or very different races of the same species), to greater or less aversion to commingling between the two more diverse sorts of particles, whereby they would remain in two separate groups and affect ontogeny uniformly and equally.

Xenia, or the communication of paternal characters to parts of the mother plant in the immediate neighborhood of the developing embryo, was held to be well established in case of some races of maize by the work of Dudley, Savi, de Vilmorin, Hildebrand, Körnicke, Sturtevant, Burrill, Kellerman and Swingle, McCluer, Tracy, Hays, and others, and in case of some races of peas, by the work of Wiegmann, Gärtner, Berkeley, Laxton, and Darwin. The converse phenomena of the mother plant influencing the characters of the developing embryo are occasionally reported, for instance in hybrids of Digitalis by Gärtner, and in hybrids of Nymphæa by Caspary.

These phenomena are inexplicable by most of the current theories of heredity and perhaps in consequence have been neglected. They necessitated the assumption that hereditary influences can be transported from cell to cell for some distance. The suggestion was made that this transport may occur either along the intercellular filaments which pass through the walls, or by means of diffusible substances capable of acting on the hereditary particles of distant cells. Townsend's proof of the conduction of the stimulus which results in wall formation, over long slender threads of protoplasm in plasmolyzed cells, may be considered as hinting at the possibility of the former explanation, while Beyerinck's claim, that the developing larvæ of some gall insects secrete substances which diffuse into and control the ontogeny of neighboring meristematic or partially developed tissue cells of the host plant, furnishes some ground for the latter hypothesis.

11. *The variable effects of hydrocyanic acid gas on plants and animals:* Mr. Albert F. Woods, Department of Agriculture.— Plants of various families and in different stages of growth were subjected to varying amounts of hydrocyanic acid gas, and were found to be affected by it in different degrees, according to the kind of plant, its age, and other conditions of growth and development. Animals, mainly insects, were also found to vary, even within the same family, in like manner. Mites were the most resistant of any of the organisms studied, often recovering after several hours of complete paralysis and apparent death.

12. *Effect of alternating dryness and moisture on the germination of some seeds:* Mr. A. J. Pieters, Department of Agriculture.—The experiments recorded are preliminary to more extensive ones now in progress, but they show clearly that for some seeds germination is quickened by thorough drying after a long period of dampness. In most cases, after a small percentage of germination for the first one hundred days or more, drying for two weeks, followed by wetting, resulted in a germination of from 15 to 54 per cent. in a few days. In the check pots, meanwhile the seeds either did not germinate, or only a small percentage did so.

13. *Experiments on the morphology of Arisæma triphyllum:* Professor Geo. F. Atkinson, Cornell University.—Female, male and neuter plants, the history of which was known by growing them in pots for one season, were potted, some in rich soil and others in poor soil, the object being to change them from male to female, etc., by varying amounts of nutriment. Male plants in rich soil were in one year changed to female, and large neuter plants in rich soil were changed to female.

In a second series, large two-leaved female plants, with large bulbs, were selected at the time the fundament of the flowers was formed. The bulbs were cut so as to remove all but a small portion in connection with the bud. By this removal of the larger part of the stored food the plants were changed to male.

14. *On polyembryony and its morphology in Opuntia vulgaris:* Dr. W. F. Ganong, Smith College.—The author has found this species markedly polyembryonic, the polyembryony having a double morphological basis. One set of embryos comes from a mass of tissue which appears to develop from the fertilized egg cell, the others spring from the wall of the embryo sac but not from the nucellus, and probably arise from endosperm cells, which if true is a mode hitherto unknown. The literature of the subject was summarized and some remarks given upon the significance of polyembryony.

15. *Contributions to the morphology and biology of the Cactaceæ. Part II.—The comparative morphology of the embryos and seedlings:* Dr. W. F. Ganong, Smith College.—This paper is a continuation of the author's earlier studies upon this family. It describes and figures germinated embryos of most of the genera and many important species, discusses the germination and growth of the embryos, their form- size- and color-factors, and the features they show of importance for the determination of the phylogeny of the genera, the development of the seedlings, and the unfolding of the peculiar morphological features of the adult plants.

16. *The morphological significance of the lodicules of grasses:* Dr. W. W. Rowlee, Cornell University.—A study of the flowers of the bamboos leads to the conclusion that the lodicules of grasses represent a reduced perianth. The three lodicules in the flower of Arundinaria alternate on the axis with the stamens, and may therefore be considered the inner whorl or petals. The stamens are directly opposite the midribs of the carpels and indicate that the inner whorl of stamens, present in some bamboos, is suppressed in Arundinaria. Hackel, as is well known, interpreted the lodicules as distichous bracts.

17. *Observations on the American squaw-root* (*Conopholis Americana* Wallr.): Dr. Lucy L. W. Wilson, Philadelphia.—An exhaustive study of the vegetative and reproductive parts had been made, but an account of the former only was read. The invariable host plant was the oak. The extreme degradation of the parasite, and the intimate relation between it and the oak roots caused the author to compare it with members of the Balanophoreæ and Rafflesiaceæ, rather than with parasitic members of the Scrophulariaceæ: The seedling parasite seemed early to attack young oak roots, and steadily grew for ten to twelve years, until a huge mass six inches across might be formed. This mass was chiefly characterized by the abundance of sclerenchyma patches, developed by the oak host through the irritant

action of the invading parasite. The presence of stomata on the stem and their absence on the scale leaves was pointed out, while the double circle of bundles traversing the flowering stem was peculiar in that the xylem of these faced each other.

18. *Water storage and conduction in Senecio praecox from Mexico*: DR. JOHN W. HARSHBERGER, University of Pennsylvania.—*Senecio praecox* (Cav.) DC. is a composite plant inhabiting the volcanic beds of the valley of Mexico. It has a cylindrical, succulent, woody stem rising three or four feet from the ground, with clustered deeply lobed leaves at the top. The plant stores up an abundant supply of water in the pith, which is gradually used up during the dry season in Mexico, which lasts from October to June. The flowers develop in April at the expense of the reserve supply of water. Loss of water during the dry season is prevented by the fall of the leaves, and by protective cork and balsam, the latter secreted in the exocortex and endocortex. The water, stored in turgid disks of pith, is gradually conducted by the woody cells and tracheids which penetrate into the medulla by wedge shaped ingrowths, representing the primary bundles, to the growing point where it is used. That this is the case is shown by the dry parchment-like pith membranes which were left in a piece of a stem which had remained in the dry state for over sixteen months. Conduction of water in the stem was accomplished without assistance of root pressure, and without any appreciable influence on the part of the small green leaves in drawing up the liquid by aid of the transpiration current.

19. *Notes on the embryology of Potamogeton*: MR. K. M. WIEGAND, Cornell University.—*Potamogeton pauciflorus* was studied with reference to the origin and development of the embryo sac, fertilization, and development of the embryo. The embryo sac was found to arise in the usual manner for monocotyledons, viz., from the subepidermal cell after the cutting off of a tapetal cell. The egg apparatus and antipodals were

however, somewhat abnormal. Although the normal number of cells in each was present, they were formed irregularly. The polar nucleus and first and second synergids seem to have been cut off successively from the mother nucleus of the egg. The synergids disappear almost immediately. A similar irregularity was found in the antipodals; but the most interesting feature, perhaps, was the fact that the definitive nucleus cuts off a very large basal nucleus, as in Sagittaria, before endosperm formation proceeds in the upper part of the sac.

20. *Recent experiments and observations on fruit production in Amphicarpæa:* Dr. Adeline Schively, Philadelphia Normal School.—This paper detailed the author's recent studies on the hog peanut (*Amphicarpæa monoica*). Her published observations showed that minute aerial cleistogamous flowers, when buried, produced one-seeded "nuts" with soft fruits and seed coats, instead of the two to three-seeded pods with indurated walls. She now showed that when purple flowers were buried in the bud state, while still attached to the plant or at any period up to the time of fertilization, perfect underground "nuts" matured, instead of three to four-seeded indurated pods. Various conclusions were drawn as to the powerful action of environmental agents in determining the size, shape, and consistence of the seed, the induration of its coats, and the number of seeds that might be produced.

21. *On the formation of cork tissue in roots of the Rosaceæ:* Dr. Martha Bunting, Philadelphia High School.—Starting from observations on *Geum urbanum* and *G. rivale*, made by Professor Macfarlane in 1890, when intercellular spaces were shown to exist between cork cells, Dr. Bunting proved this condition to be typical for all herbaceous and shrubby species examined, but to be absent in roots of arborescent species. She described the alternation of a flattened, usually pigmented layer of cells, with one to three layers of rounded cells in each annual ring, the flattened layer being the last produced each season. Protoplasm,

nuclei, and starch grains existed in cork zones four to five layers removed outside the phellogen.

22. *The structure and developmant of internal phloem in Gelsemium sempervirens :* Miss Caroline Thompson, University of Pennsylvania.—The author showed that the internal phloem originated as four longitudinal tracts in the primary meristem and steadily increased until by the eighth or tenth year it had entirely pressed together and destroyed the pith. During the first year nourishment of the pith ceased, owing to the differentiation of two layers of cells, which were referred to as the "phloem sheath."

A remarkable distribution of the internal phloem was shown to exist in the petiole, at the base of which a bicollateral bundle arrangement existed, but this quickly changed to the ordinary collateral relation by the passage of the upper (internal) phloem through the xylem of the petiole. Each bundle in passing out into the petiole subdivided into three parts, two of which remained in the stem and soon came together again, while the third passed out and behaved as above described.

From the second year onward, the internal phloem patches of the stem show areas of crushed and obliterated tissue, where the previously formed phloem had been pushed inwards by the younger elements. In older stems eight large phloem patches formed by division of the original four, entirely filled up the pith area.

BRIEFER ARTICLES.

THE TREE OPUNTIAS OF THE UNITED STATES.

Three species and two varieties of the cylindrical opuntias of the United States may very properly be termed trees. The species and varieties here designated are *O. fulgida* Engelm., *O. fulgida mammillata* (Schott) Coult., *O. versicolor* Engelm., *O. spinosior* (Engelm.),[1] and *O. spinosior neomexicana*, var. nov.[2]

O. fulgida is a well-marked species with characters constant and well defined. There is little danger of mistaking this species for others when it is once known. The specific characters of *O. fulgida* are substantially as given by Dr. Engelmann.[3] Although this species has been found as far north as southern Nevada,[4] within the borders of the United States it is confined almost entirely to Arizona, south of the Colorado plateau.[5] It is a plant of the plains and evidently reaches its greatest development on the mesas about Tucson, at an elevation of

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✓[1] **Opuntia spinosior** (Engelm.) (*O. Whipplei spinosior* Engelm. Syn. Cact. 307. 1856).—A small tree 25 to 35^{dm} high, trunk 12 to 25^{cm} in diameter, with dark brown, thick, rough bark, with numerous very spiny verticillate branches forming a spreading top: joints cylindrical, varying in color from green to purple, ultimate ones 5 to 20^{cm} long, about 2^{cm} in diameter, the short, broad, prominent tubercles slightly crested, elevated 3 to 6^{mm} and from 8 to 14^{mm} long: pulvini oval, with short, light colored wool and a few short light-brown bristles at upper margin: spines 5 to 15 on ultimate joints, 30 to 50 on older joints, 5 to 15^{mm} long, the interior ones occasionally longer, closely sheathed, reddish-brown, the sheaths white and glistening: the flower purple, 5 to 7^{cm} broad, with broad obovate petals: fruit in whorls at extremity of branches, oval rarely globose or hemispherical, 3.5^{cm} long and 2.5^{cm} in diameter, bearing about 25 tubercles, unarmed, fleshy, with acid flavor, yellow: seeds regular, smooth, 4^{mm} broad, with linear commissure.

✓[2] Opuntia spinosior **neomexicana**, var. nov.—Growing with and of the same size as the species: tubercles longer: spines more numerous and looser sheathed: flowers yellow to red, with petals much narrower and fewer than in the species: fruit longer and frequently tinted with red.

[3] Cactaceæ Mex. Bound. 57.

[4] Contributions from U. S. National Herbarium 3:448.

[5] Garden and Forest 8:324.

from 2000 to 3000 feet. Here an occasional specimen is found a trunk twelve inches in diameter three feet above the ground, and being a well formed top with wide spreading branches.

The bark of the trunk and larger limbs is thick, rough, a entirely destitute of spines, the spines falling away with the ou layers when the branches are about four inches in diameter. It va in color from almost black to yellowish brown, depending upon thickness and age. The terminal joints are very succulent and alm devoid of woody tissue. They are easily detached and usually deve roots after falling to the ground, establishing themselves as indepe ent plants.[6] The tubercles on a joint of the first season's growth b from five to fifteen loose-sheathed spines, but in common with m other species of cylindrical opuntias, several spines develop at upper margin of each pulvinus during the season's growth, so tha tubercle on a stem several years old may bear as many as forty or ev sixty well developed spines.

In Dr. Engelmann's description and in the account of this pl as given by most writers the flowers are said to be purple. They a however, purple only when dried or withered. In fresh condition th are bright pink. The plant of Lower California referred to this spe is said by Mrs. Brandegee to have yellow flowers.[7] When fully o the short petals are strongly reflexed. In Arizona this plant does n bloom until July, and from this time flowers may be found until la in September. The early flowers develop from the tubercles at t ends of the joints of the previous year's growth, while the later o grow from the terminal tubercles on the immature fruit. This pro may go on through six or seven series during the months of J August, and September until the proliferous fruit hangs from t stems in pendulous clusters, sometimes as many as seven fruits i single cluster, one growing from the other in continuous succession

Occasionally a fruit will remain attached to the plant for the sec year, and flowers develop from the tubercles of the old fruit. In a instances I have found a branch growing from a tubercle on a nor fruit. If a fruit not fully ripe be placed on moist sand, roots will g from the lower tubercles and either flowers or branches from the upp ones, forming an independent plant without the growth of the see within. Fruits attached directly to the stems are usually larger a contain perfect seeds, while the secondary ones are generally sterile; however, an entire cluster may sometimes be found with perfect seeds.

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[6] Vegetal dissemination in Opuntia, Bot. Gaz. **20**: 356.

[7] Notes on Cacteæ, Erythea **5**: 122.

Cattle feed upon the succulent spineless fruits, but in doing so the burr like terminal joints frequently become detached and adhere to their heads, the innumerable barbed spines piercing the flesh and causing injurious wounds if not removed. Many small bristles cover the pulvini of the fruit at maturity and accumulating in the stomachs of the cattle feeding upon them produce large phyto-bezoars. In color the fruit at maturity is pale green, a little lighter shade than the epidermis of the stem or immature fruit.

The plant illustrated in *Garden and Forest* 8:325 was removed some eighteen months ago from the mesa to the cactus garden of the University. Although the plant is one of the largest specimens in this vicinity and at least one hundred years old, it did not seem to suffer from transplanting. In this specimen the entire root system, with the exception of a few long surface roots, was a mass of short fibers springing directly from the trunk a few inches below the surface of the soil, none reaching to a greater depth than two and one-half feet.

What has been said of *O. fulgida* applies almost equally as well to *O. fulgida mammillata.* The differences seem to be in that the variety has thicker, shorter joints; fewer, shorter spines; more prominent, shorter tubercles; and is a plant of the foothills instead of the open mesa.[8] The description as given by Dr. Coulter[9] gives the variety as more tree-like than the species. In my observations the reverse is true. Although the spines on the terminal joints are usually four to six, older ones may have twenty or thirty to the tubercle. The flowers and fruits are practically identical.

O. versicolor Engelm. is the most abundant cylindrical opuntia on the foothills and low mountains of southern Arizona. It is a small tree with trunk eight inches in diameter in well developed specimens, and bearing many irregular branches with terminal joints sometimes two feet in length. It has smooth, light-brown bark, without spines on the trunk and older limbs. The epidermis of the younger branches is dark-green to purple. The terminal joints are intermediate in diameter between *O. spinosior* and *O. tetracantha*, while rather prominent tubercles are intermediate in length between *O. arborescens* and *O. spinosior.*

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[8] Garden and Forest 8:324.

[9] Contributions from the U. S. National Herbarium 3:449.

The short, brownish spines have inconspicuous sheaths and va in number from four to fourteen on young joints, while on older ste there may be as many as twenty-five to a single tubercle. The flowe appear in May, expanding to nearly an inch and a half in diamete the comparatively narrow petals varying in color from greenish-red greenish-yellow.

The fruit ripens from December to February, usually withering a drying on the tree. Sometimes it does not dry but remains fles adhering to the branches until late the next summer or in so instances for longer than two years. At maturity it frequently sp open, showing the many angular seeds within. It is not unusual f fruits that remain to become proliferous the second season. It var remarkably in size and shape, but is usually pear-shaped and from o to two inches in length. A form of this plant growing on the fo hills of the Santa Catalina mountains bears fruit less than three-four of an inch in diameter and almost perfectly spherical. The color the mature fruit is the same as that of the stems, never yellow as related species. The pulvini are all toward the apex of the fruit, an usually growing from them are one to three reflexed, persistent spin a half inch or less in length. In many specimens, however, the fr is spineless. The seeds are irregular and angular, a character comm to species with dry fruits.

Considerable confusion exists regarding the geographical distri tion and specific characters which separate *O. Whipplei* Engelm., *arborescens* Engelm., and *O. spinosior* (Engelm.), the latter an inte mediate species heretofore considered as a variety of *O. Whipplei.* *Whipplei* is a species of the Colorado plateau,[10] growing at an eleva of from 5000 to 7000 feet. As I understand this species I have nev found it growing south of this plateau. In Dr. Engelmann's accou of this plant,[11] under the brief description of the variety we are referr for illustration to *pl. 17, figs. 1–4.* Turning to this plate the figur indicated are marked *O. Whipplei.* The illustration is an excelle representation of the plant of the Colorado plateau and unques tionably represents the species instead of the variety. In the descri tion of the species we are referred to *pl. 17, figs. 5–6* and *pl. 17, fi* Turning to these plates we find the figures marked *O. arboresc* Here again there is confusion, but by comparing the plant of southe Arizona with these illustrations I conclude that they were made af material collected here and really represent what has been known as *O. Whipplei spinosior* Engelm.

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[10] Garden and Forest 9: 2.

[11] Pacific R. R. Report 4: 51.

O. Whipplei is a low, spreading bush, never arborescent and rarely more than two or three feet in height. The joints are usually somewhat clavate, and the spines are covered with white, glistening, loose sheaths, which gives the plant a characteristic appearance and readily separates it from related species. The flowers are not red as stated by Dr. Engelmann and followed by Dr. Coulter in his preliminary revision, but a yellowish-green, and when fully expanded barely an inch in diameter. From the original account of the species and variety I infer the description of the flower was drawn from material collected by A. Schott south of the Gila river, and represents the plant designated as the variety *spinosior*, which has much larger purple flowers. The fruit of *O. Whipplei* is hemispherical and less than an inch in diameter. It ripens during the winter months and usually shrivels and dries on the plant.

O. spinosior is not only specifically distinct from *O. Whipplei*, but has a well marked variety in southern Arizona, viz., *O. spinosior neomexicana*. This southern species and variety are low growing trees with spreading tops. By most writers the species has been confused with *O. arborescens*. In my account of *O. arborescens*[12] the plant illustrated is really *O. spinosior*, while the form with smaller flowers having fewer and narrower petals varying in color from red to yellow is the above variety.

The flowers and fruit of *O. spinosior* are practically the same as in *O. arborescens*, but the two species are readily separated by the long, high crested tubercles of *O. arborescens* when compared with the short almost mammillate ones of the former species. The latter species is a much smaller and more eastern plant, never approaching a tree in size, at least in the United States. I have measured specimens of *O. spinosior* in the vicinity of Tucson with trunk two feet from the ground a little over nine inches in diameter. The plant grows with *O. fulgida* on the open mesa, seldom reaching the foothills, where its place is taken by *O. versicolor*. The trunk and larger limbs are spineless, but are covered with thick, rough, dark-brown bark in elongated ridges. The flowers appear in April and May, and the fleshy fruit ripens during the following winter and spring. The large, conspicuous, deep-purple or magenta flowers, like all other species of this section known to me, have sensitive stamens, which, when disturbed close tightly around style a few lines below the stigma.

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[12] Garden and Forest 9 : 2.

An average fruit has from twenty to thirty tubercles, at first arm with a number of slender spines, which are deciduous in November an December, when the fruit begins to turn yellow.

The tubercles of the immature fruit are very prominent, but as fruit ripens it increases considerably in size, becoming more succulen and as a result the tubercles become much less conspicuous, sometim entirely disappearing, leaving the fruit smooth save for the small bris covered pulvini. The oval fruit when ripe is frequently two inch long, and one and one-half inches in diameter, well filled with smoo seeds similar to those in *O. arborescens.* As with *O. versicolor* the fru occasionally remains green for the second year and becomes prolif ous. It is clustered at the extremity of the stems of the previous yea growth, and when ripe the verticillate branches are pendulous from weight.

The variety grows with the species, and its general form and hab of growth is somewhat similar.—J. W. Toumey, *University of Ari*

WINTER CHARACTERS OF CERTAIN SPORANGIA[1]

(WITH PLATE XI)

The gross characters of winter buds have been studied for a long time, but the histological characters of the sporangia have receive comparatively little attention. It is an unfortunate fact that ma otherwise excellent morphological papers are marred by incomple ness, and perhaps this is nowhere more apparent than in the case those sporangia which attain some degree of development before winter sets in, pass the cold season in a quiescent state, and resu development in the spring. It is hoped that the description of a som what miscellaneous collection of sporangia will not only show in wh condition many buds pass the winter, but will incidentally ena students to make their series complete without waiting until the ne year to fill in the gaps. The study of these dormant sporangia m also throw some light upon the significance of the resting stage nuclei and cells. All the material upon which the following obser tions are based, excepting Marsilea, was collected in the vicinity of Chicago.

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[1] Contributions from the Hull Botanical Laboratory. VIII.

OSMUNDA CINNAMOMEA L. — Rhizomes with strong buds were dug up November 11, 1897, the woolly covering was removed, and small parts of fertile branches were killed in chrom-acetic acid. The entire absence of mitotic figures showed that cell division had ceased. The average condition of the sporangia is shown in *fig. 1*. The sporogenous tissue has reached the spore mother cell stage, but the cells are still sharply angular, not yet showing any tendency to assume the spherical form which precedes division into tetrads. The cytoplasm is dense and not at all vacuolated. None of the nuclei show synapsis, but the chromatin is evenly distributed. There are usually two or three nucleoli. Some of the nucleoli are cyanophilous and others erythrophilous, even in the same nucleus, but on the whole one kind or the other predominates in any given sporangium. In both kinds there is considerable variation in the intensity of the stain, an indication that the nucleoli are undergoing changes. The tapetal cells, while rather poor in contents, are not breaking down like the cells between the tapetum and the epidermis.

MARSILEA QUADRIFOLIA L.— In the mature sporocarps collected November 10, after the leaves had rotted, both microspores and macrospores had nearly reached their full size, but were still uninucleate, germination under natural conditions not beginning until the next spring.

SELAGINELLA APUS Spring.—The development is carried further than in Marsilea, the prothallium attaining considerable size before the macrospore is shed.

PINUS LARICIO Poir.—Several stages were studied. Microsporangia gathered in October, January, and the following April are represented in *figs. 2.3* and *4* respcetively. All are in the spore mother cell stage. This may be known by the fact that in a section of a sporangium the number of cells within the tapetum corresponds with the number of tetrads in late April sporangia. Guignard's rule that when the tapetum is differentiated the sporogenous tissue has reached the spore mother cell stage is sustained by all the microsporangia which I have examined. In October specimens (*fig. 2*) the spore mother cells have several small nucleoli which are quite uniformly cyanophilous. In the January material (*fig. 3*) the nucleoli are very inconspicuous, but reappear as the nuclei resume their growth in the spring (*fig. 4*). This figure shows three nuclei in synapsis, while the other nuclei have the large size and prominent chromatin network which marks appro ing division. The tapetum, now much compressed by the growing sp mother cells, is more sharply marked than in the January prepara Collections of May 4 had the macrospore developed almost to formation of archegonia.

PINUS BANKSIANA Lambert.—About a dozen macrosporangia, lected May 14, showed the macrospore mother cell, but mate collected in a neighboring locality two weeks earlier showed an en sperm of several cells. Mitotic figures are very frequent in al these spring collections, so that it is very possible that the macros rangia also pass the winter in the spore mother cell stage.

CUPRESSUS LAWSONIANA Murray.—October microsporangia sho pretty uniformly the condition represented in *fig. 5*. The nucl the spore mother cells usually have a single prominent nucleolus w which is cyanophilous. No macrosporangia were studied.

TAXUS BACCATA CANADENSE Willd.—The microsporangia reached the spore mother cell stage in October (*fig. 6*), but the nu were still rather small in comparison with the size of the cell. tapetum is sharply differentiated, and its cells show no tenden plasmolyze like the other cells of the sporangium wall. The ma sporangia were not studied.

TRILLIUM.—Miss Arma Smith[2] found microsporangia of lium in the spore mother cell stage in buds taken from beneath frozen soil on April 5. In one case the mother cells were un going division. This suggests that cell division, which I feel cer does not take place under our usual winter conditions, may be resu while the temperature is still near the freezing point. The pres writer found the four potential macrospores in *T. recurvatum* colle April 10, at which time the plants were about two inches high.

HEPATICA ACUTILOBA.—Mottier[3] reports that material of this spe collected in the middle of November was already too far advance studying the earlier stages of the embryo sac. Some of my mate collected September 27 was young enough for the study of development, while the largest buds showed microsporangia in pollen mother cell stage. Another collection taken in the sp while the ground was still frozen had pollen fully formed and en sacs ready for fertilization. It hardly seems probable that a macrosporangium would pass the winter in this stage.

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[2] Abortive flower buds of Trillium. BOT. GAZ. 22: 402. 1896.

[3] Contributions to the embryology of the Ranunculaceæ. BOT. GA 298. 1895.

SALIX.—Two years ago I studied a very complete series of microsporangia and macrosporangia in Salix[4] This series, containing sporangia collected in nearly every month of the year, showed that the microsporangia pass the winter in the spore mother cell stage. The midwinter pistillate flowers showed considerable variation; in some even the rudiment of the nucellus could not be distinguished, while in others the archesporium may have been present. Undoubted macrospore mother cells were not found until growth had been resumed in the spring.

POPULUS.—This genus shows practically the same conditions. Staminate flowers of *P. monilifera* Ait. collected in July showed the primary sporogenous cell. In October the sporangia had reached the spore mother cell stage, and could hardly be distinguished from the midwinter condition represented in *fig. 7*. No undoubted macrospore mother cells were found until growth had been resumed in the spring.

CORYLUS AMERICANA Walt.—Midwinter catkins showed the pollen grains apparently ready to be shed. The division into the tube nucleus and generative nucleus had already taken place (*fig. 8*).

ALNUS GLUTINOSA Willd.—This species showed about the same conditions as the last. The winter microsporangia appear so nearly like those collected just before the shedding of pollen in the spring that one figure might represent them both (*fig. 9*).

These examples are sufficient to show that sporangia of various plants pass the winter in very different stages of development, and it seems probable that all plants of a given species in a given locality pass the winter in about the same stage of development.

The spore mother cell seems to be a very usual halting place in the development of sporangia, but whether this is because the spore mother cell is better able to withstand unfavorable conditions, or for some other reason, it is at present impossible to decide. It has been noted by cytologists that the spore mother cell, in which the reduction of chromosomes takes place, requires a longer resting period than do the cells which precede or follow it. This may be seen even in annuals where the resting period is comparatively short, and is easily observed in those biennials and perennials which pass through all stages from floral development to seed in a single season. It is certain, however, that so long a period is not needed, since many plants which h reached the spore mother cell stage in the autumn resume th development when brought into the laboratory early in the wint Again, my observations hardly allow the supposition that the sporan merely continue their development until checked by cold weath Of course every botanist has noticed dandelions blossoming in Dece ber and January, and fruit trees bearing a second set of flowers in la autumn. The change in the habits of north temperate plants whe taken to a warmer climate is also well known, but they doubtless s have their resting periods. I should be inclined to think that th stage at which a sporangium rests for the winter is determined larg by its power to withstand unfavorable conditions. It has been notic that the later the material is collected the more promptly it resum its development. This suggests that the resting period is not one absolute inactivity.— CHARLES CHAMBERLAIN, *The University of Chic*

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[4] Contributions to the life history of Salix. BOT. GAZ. **23**: 147–178. 1897.

EXPLANATION OF PLATE XI.

All figures are drawn with a Bausch and Lomb camera lucida, Zeiss ocular no. 2 and Zeiss apochromatic 2^{mm}, homogeneous immersion objecti The figures have been reduced by photography to one-half the size of th original drawings.

FIG. 1. Sporangium of *Osmunda cinnamomea* L. collected November 1 1897.

FIG. 2. Microsporangium of *Pinus Laricio* Poir. collected October 1896.

FIG. 3. The same, collected January 3, 1898.

FIG. 4. The same, collected April 4, 1896.

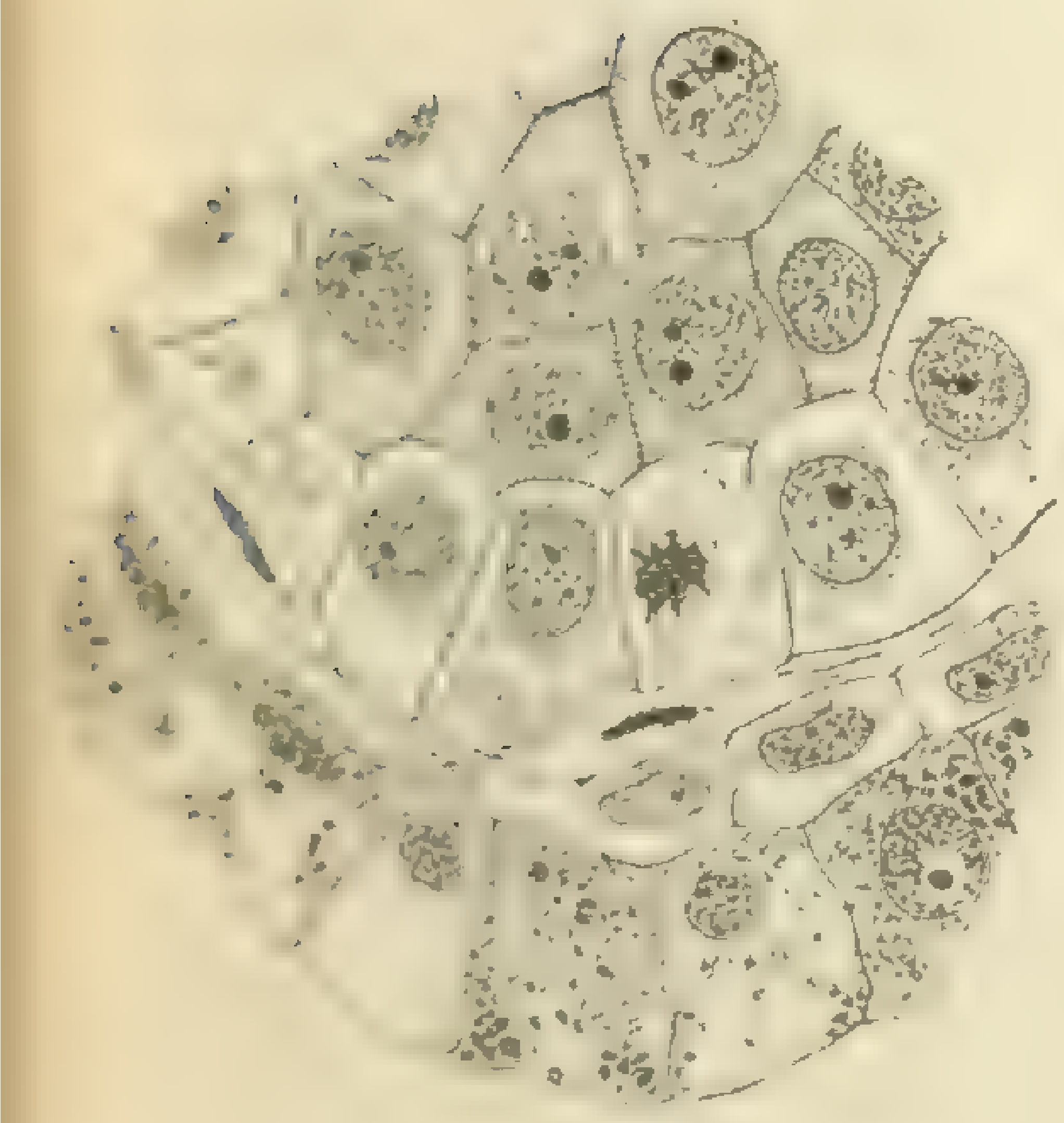
FIG. 5. Microsporangium of *Cupressus Lawsoniana* Murr., collected Oc ber 1, 1897.

FIG. 6. Microsporangium of *Taxus baccata, Canadense* Willd. collecte October 1, 1897.

FIG. 7. Microsporangium of *Populus monilifera* Ait. collected Januar 25, 1896.

FIG. 8. Microsporangia of *Corylus Americana* Walt. collected Decemb 7, 1897.

FIG. 9. Microsporangium of *Alnus glutinosa* Willd. collected April 1897.



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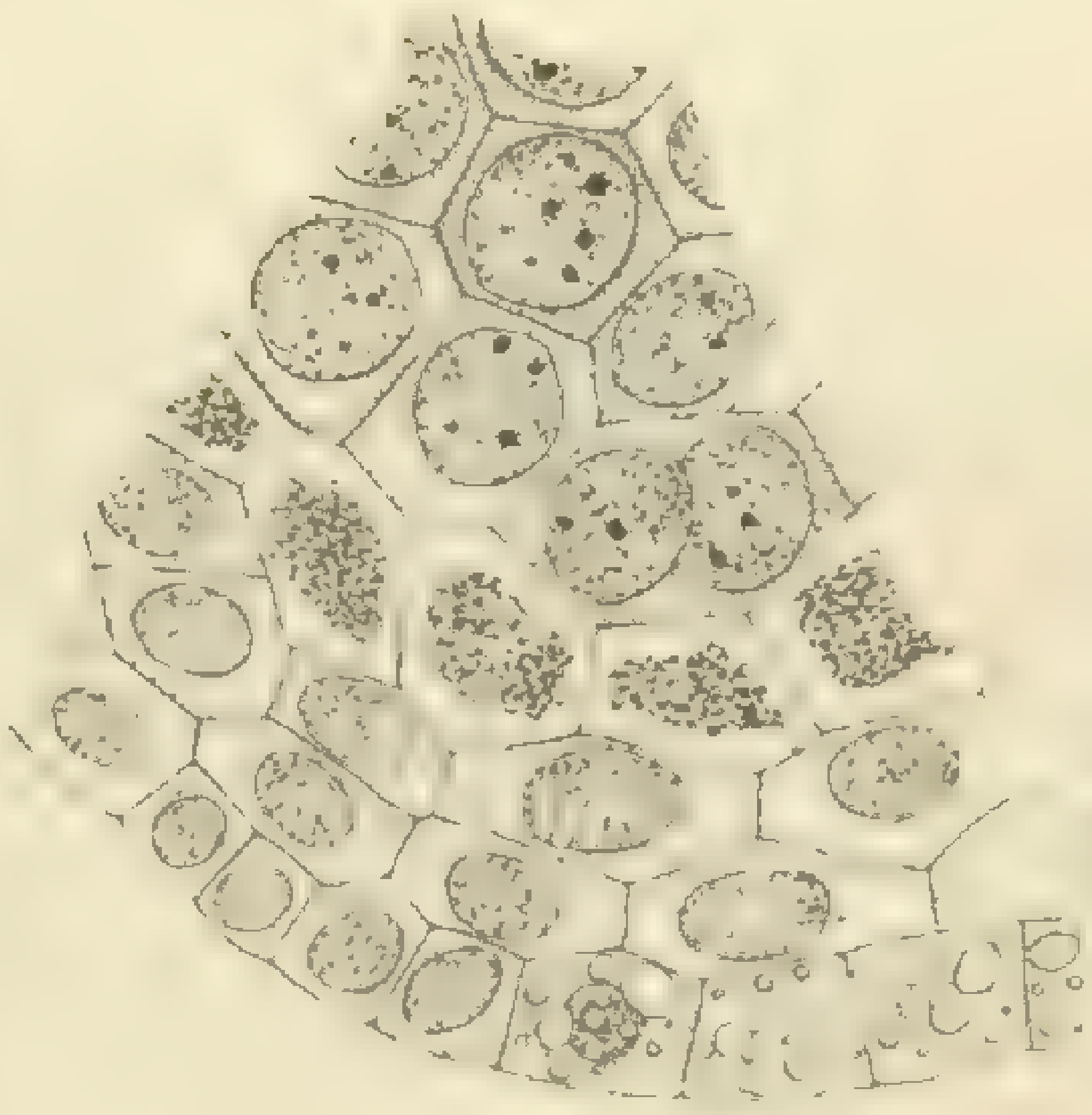

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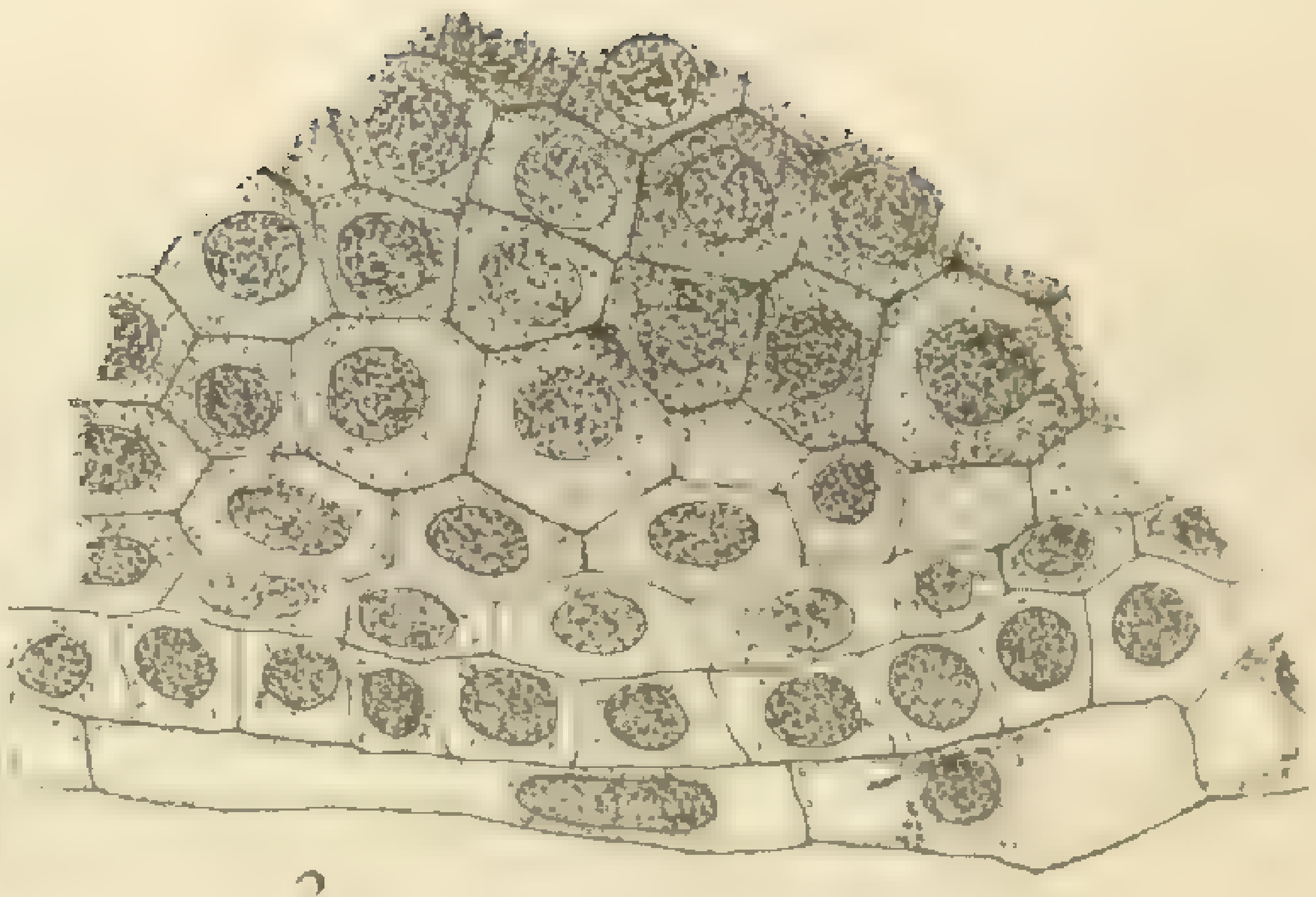

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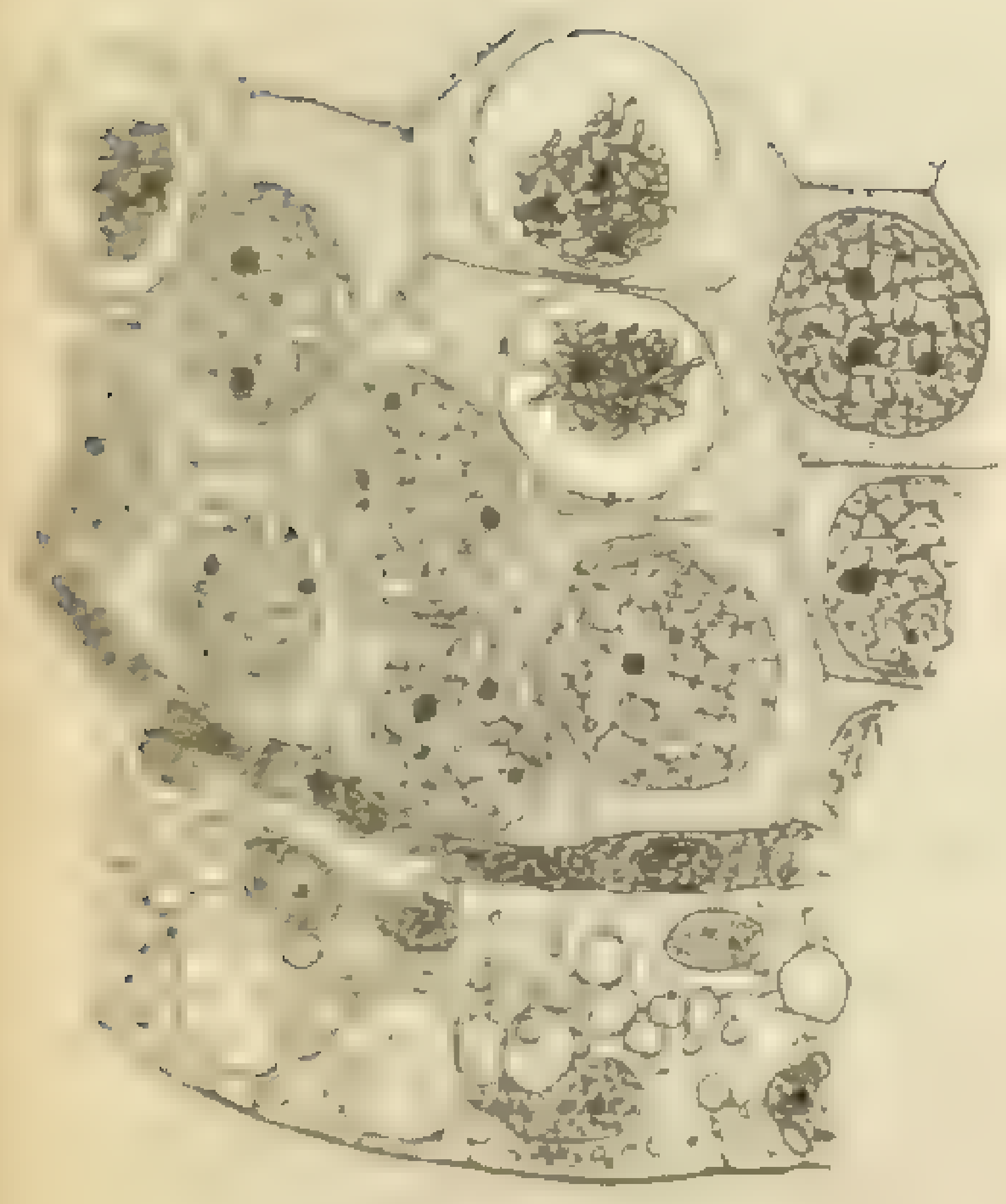

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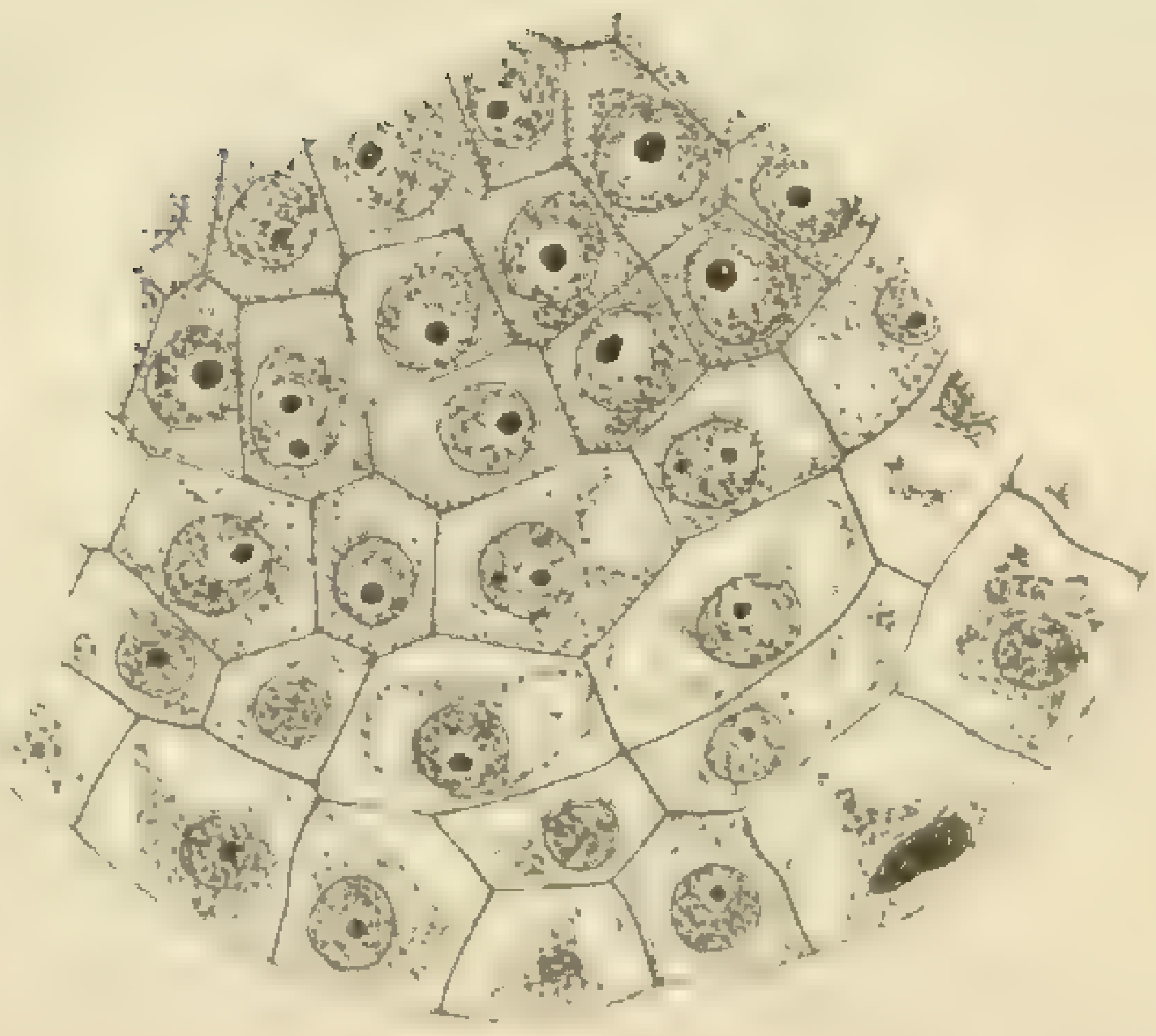

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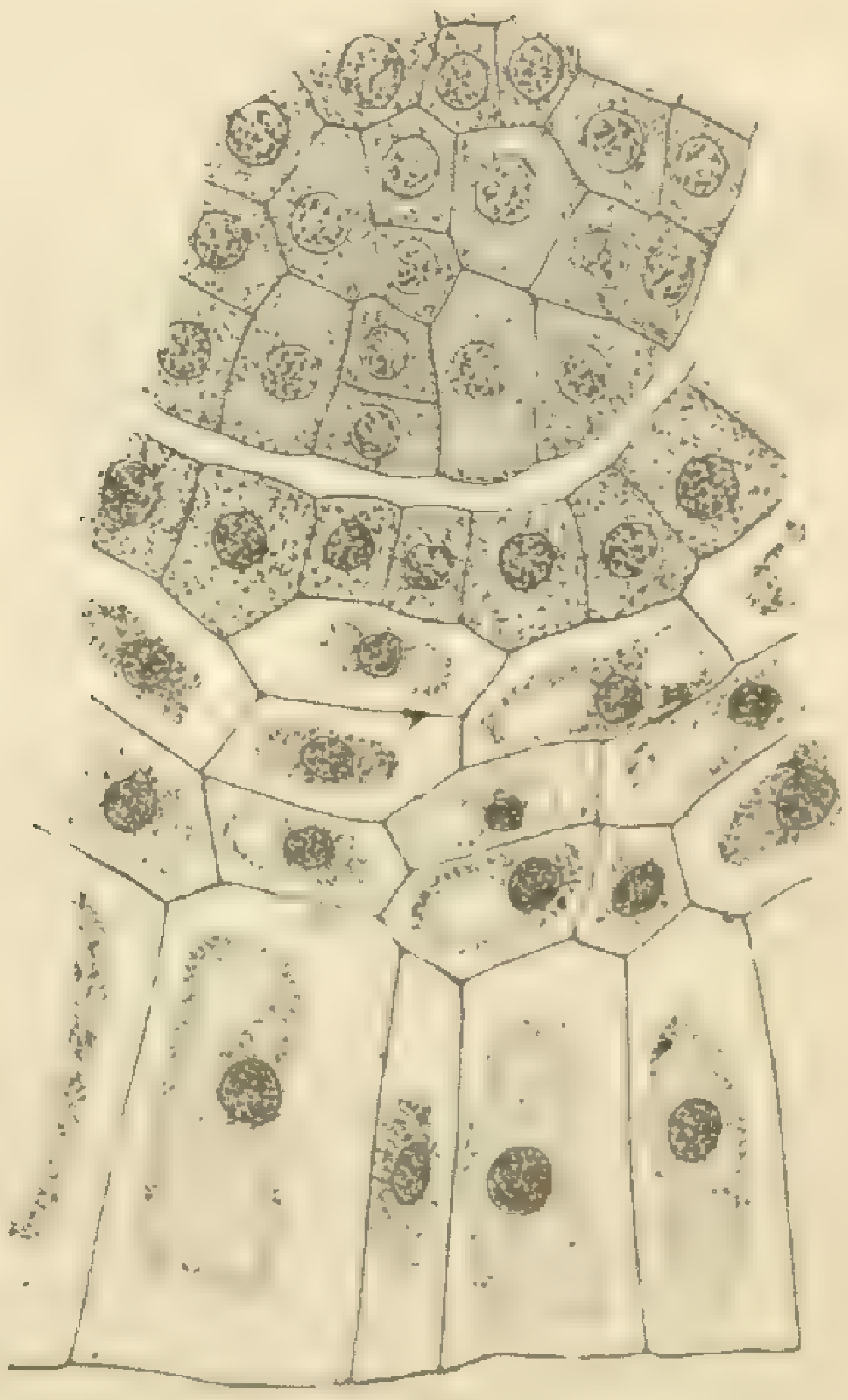

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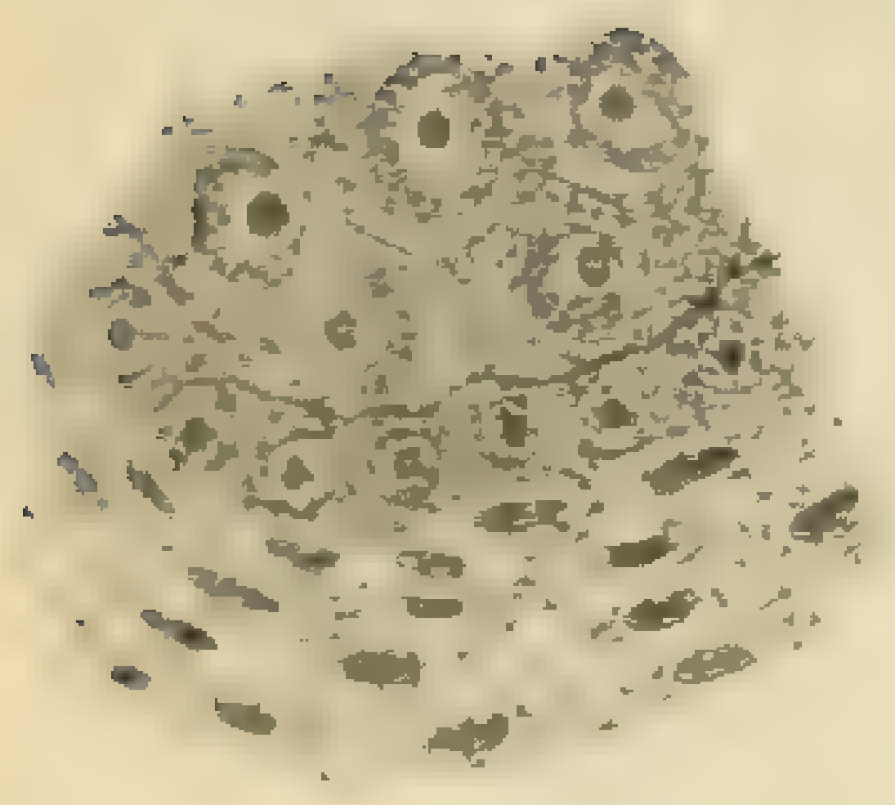

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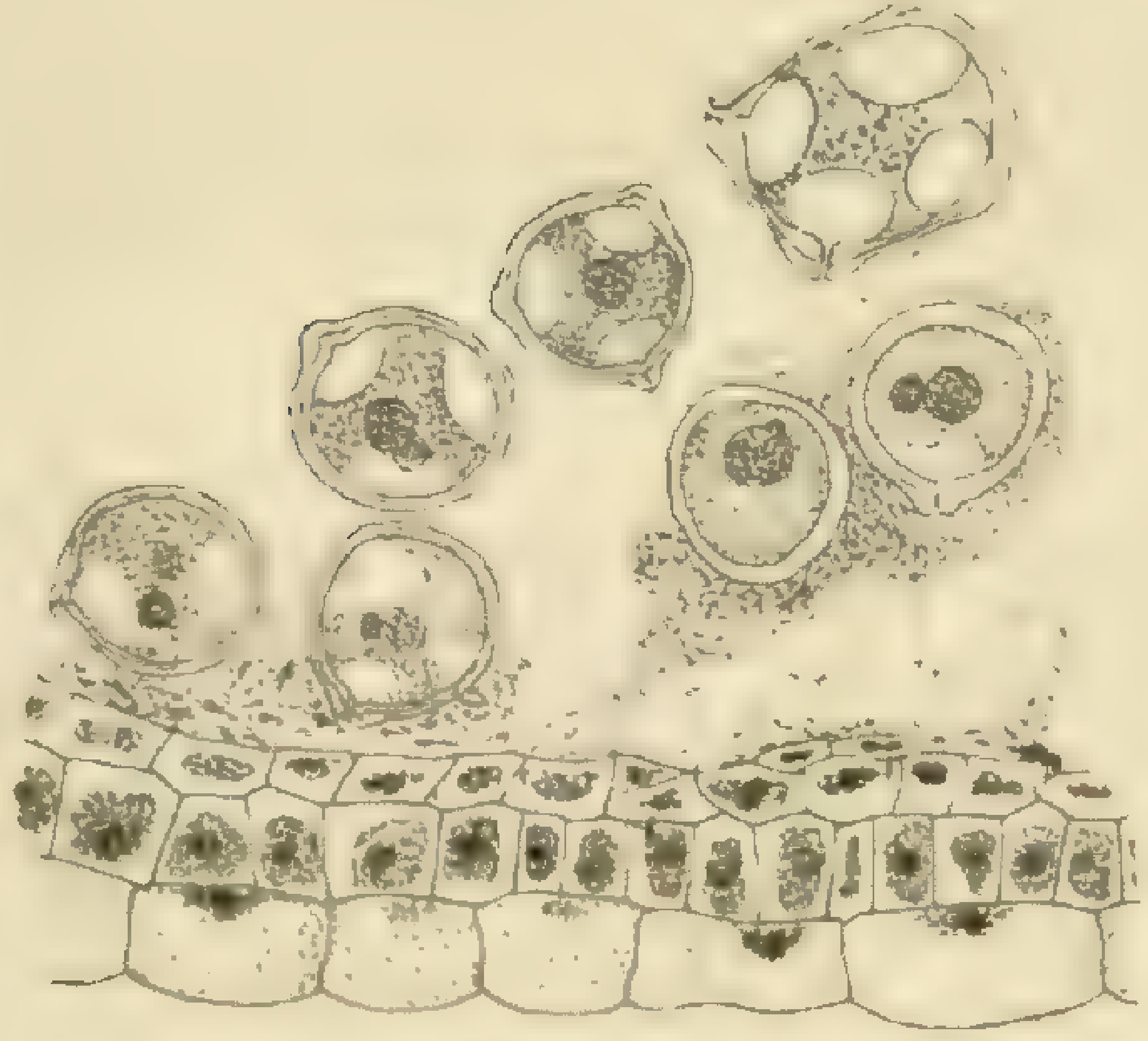

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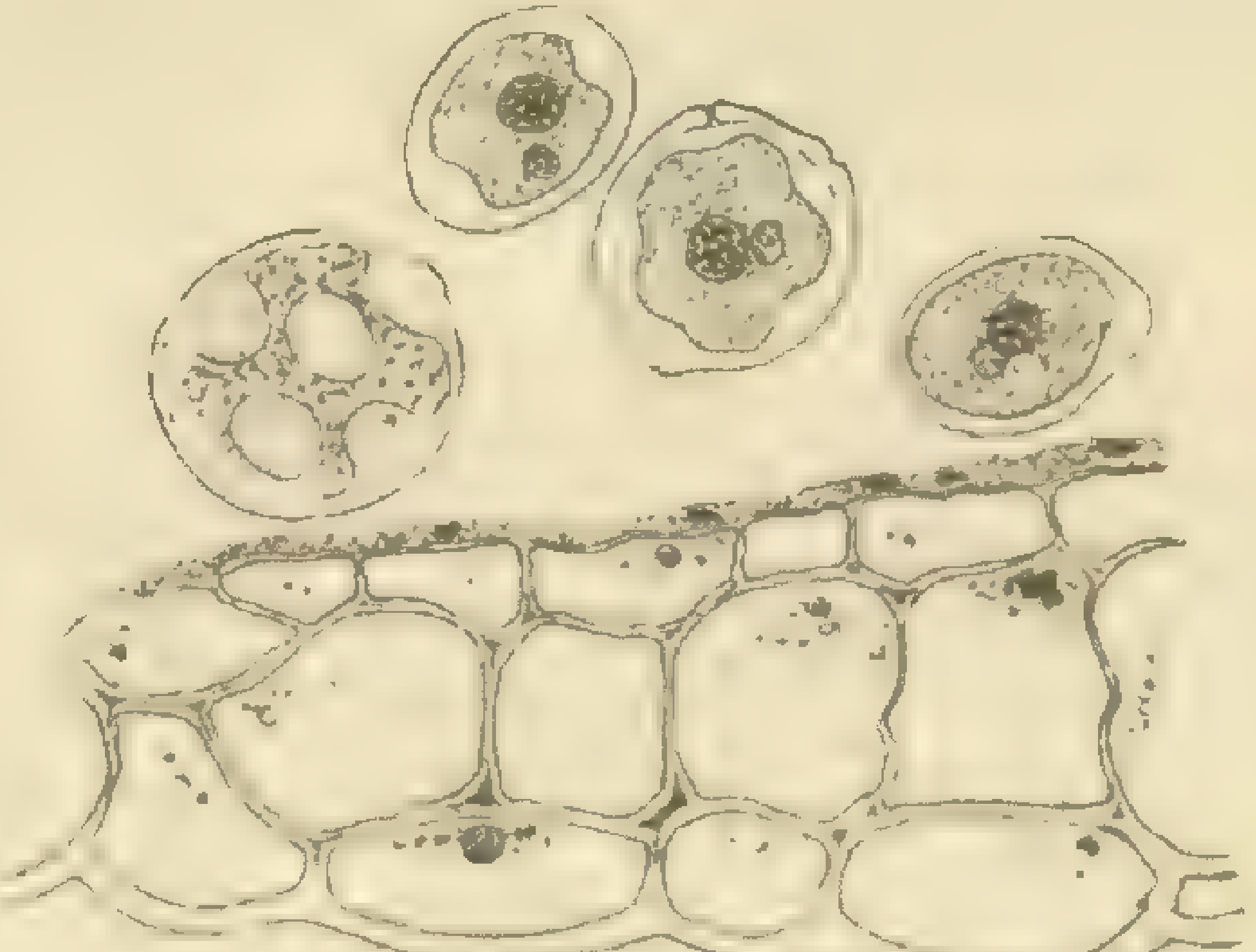

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Chas Chamberlain del.

CHAMBERLAIN on WINTER SPORANGIA.

EDITORIALS.

The Standpoint of Criticism

As the number of botanists in this country increases it is inevitable that they will cross each other's paths more and more. Up to the present each worker, except in taxonomy, has been more or less independent, and what he has had to say regarding any given subject has been accepted by his fellows, for the time at least, as substantially correct. In taxonomy, however, the number of workers has been greater; their views have conflicted, as from the very nature of the subject, they must; and from the criticisms of each other's work a considerable amount of coldness or even aversion has been engendered. In Germany one sees this condition in its extreme development; scientific men refusing to speak to those who antagonize their views on controverted points, or even absenting themselves from societies whose meetings are attended by the obnoxious opponent.

No one can believe that American botanists wish such a state of affairs to exist here. That being so, it will be well for each to exercise caution in the matter of unfavorable criticism which he may be called upon to make upon the work of his associates. It seems clear that not only the right but often the duty to pass such criticism must be maintained. It becomes a question therefore of the manner and the standpoint of criticism. As to manner, it is to be assumed that this will not pass the bounds of courtesy in the future, as it has rarely done in the past. Past sins in this respect have been chiefly in the standpoint of the critic.

What ought this to be? The prime consideration in the criticism should be the assumption that the investigator whose work is disapproved is neither an ignoramus nor an imbecile. Of course either of these states may be proven, but the evidence must be very decisive if others are to believe. Is such an assumption ever possible? Those who attended the Toronto meeting of the British Association had the opportunity of hearing one distinguished mycologist make a charge against another which could scarcely proceed from any other ass tion, so childish was the blunder imputed to him. At the meetin the American Association also a paper was read by a young man had studied the carnation disease for one year charging two bota who had studied this disease for nearly seven years with most e gious error regarding its cause. Other more remote examples occur to those who are familiar with botanical history. It may be Magnus was right and Eriksson was wrong; that Woods was righ Arthur and Bolley wrong; we cannot judge; but we wonder at attitude of mind which assumes so great possibilities of aberratio the part of another, and so few on one's own. Is it not this so criticism, which, couched in irreproachable language, proclaims in e "See what a silly blunder this man has made, and how easily I ex it," the sort that rankles and leads to estrangement? And ha done its evil work in one direction, is it not quite likely to retur a boomerang and smite its author, if, perchance, renewed investig shows him mistaken?

IF WE ARE to avoid quarrels which quickly run through To stone's seven causes, we do well to take heed that our attitude not imply the quip quarrelsome while our words contain only retort courteous.

CURRENT LITERATURE.

BOOK REVIEWS.

Pennsylvania forestry.[1]

IN these two volumes Dr. Rothrock, the efficient forestry commissioner of Pennsylvania, has embodied what may be considered almost a model method of popular education on a little known subject. Notwithstanding the immense amount of money realized from lumbering in Pennsylvania, and despite the fact that the visible supply of raw material is but a moiety of what was considered an inexhaustible forest less than fifty years ago, the popular apathy regarding forest resources is almost as great in Pennsylvania as in the northwestern states. And yet it must be said that, while other states preceded her in formulating forestry legislation, Pennsylvania has approached the subject in a more business-like way, and is already in the front rank in the protection of forest interests.

The report of 1895 embodies the work of a forestry commission appointed by act of legislature approved May 25, 1893. This commission consisted of a botanist (Dr. J. T. Rothrock) and an engineer (Mr. William F. Shunk), the latter confining his work to the watersheds of the state, and the influence of forests on stream-flow. Dr. Rothrock is responsible for much the greater part of the volume, and it would be difficult to have planned a report better calculated to stimulate popular interest in a failing resource, and to arouse public opinion to the necessity of strong legislative measures for its protection.

It is to be regretted that a book so admirable in its plan should be faulty in its statistics, but this may be pardoned in view of the brief time at the disposal of the commission. It appears that 36.29 per cent of the state area is in timber, but no indication is given of the value of this woodland, which embraces both productive forest and what is practically waste land. Forest fires and the relation of forest to water supply are discussed, and an estimate is given by counties of forest area and conditions. Much the greater part of the report is devoted to notes of a non-technical character on the commercial forest species of the state.

The illustrations are especially noteworthy, and with their graphic titles tell in themselves the story of the evil effects of forest fires and the wasteful extravagance of present methods of logging. It should be remembered that

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[1] Annual Report of the Division of Forestry, Department of Agriculture, State of Pennsylvania, for 1895, and for 1896. Harrisburg.

Dr. Rothrock has not attempted a technical discussion of the forestry problem; his evident aim is to educate the people to an appreciation of the importance and value of the forests, a purpose the report is well calculated to serve.

The second volume is a modest pamphlet of fifty-five pages, but to the teacher of forest botany, and the student of legislation for forest protection it is the more notable utterance of the two. In addition to a preliminary report as forestry commissioner, there is a popular essay on the relation of forests to the farmer and an excellent article on the removal of the fertile soil from the farm by water, both of which contain interesting material for teachers. A black walnut freak, producing fruit, the epicarp of which resembles that of the hickory nut, is described and figured, as is also a weed (*Echium vulgare*) new to the state.

In his report Dr. Rothrock discusses a practical method of securing reliable data of the various classes of timber land in the state — information not heretofore available — taxes on forest land, forest reservations, forest fire legislation, and forests and floods. The report, though brief, is by far the best presentation of forestry needs that has yet appeared, and should have wide publicity.— CHARLES A. KEFFER.

The physiology of plants.

IT HAS BEEN known for some time that Professor Dr. Pfeffer had in preparation a new edition of his treatise on plant physiology. The first volume of this second completely rewritten edition has recently appeared.[2] How completely it has been rewritten appears at once when the 383 pages of the first volume of the first edition are set over against the 620 pages of the same part of the second edition. Since the first edition has occupied so important a position in the literature of plant physiology, it is to be expected that this much more extended one will rightfully maintain the place its predecessor won.

The volume before us is devoted to the discussion of the movements and transformations of matter (*Stoffwechsel*); the second, which is in preparation is to discuss the transformations of energy (*Kraftwechsel*). After a few introductory chapters, the following are the main headings: Die Mechanik des Stoffaustausches; die Mechanik des Gasaustausches; die Wasserbewegung in der Pflanze; die Nährstoffe der Pflanze; Bau und Betriebsstoffwechsel; Athmung und Gährung; Stoffwanderung. Although so greatly extended, it will be observed that the same general mode of treatment has been retained. While details have been much altered, the fundamental outlines remain the same.

What one feels most strongly in going through the book is that the author has touched almost every section through his own investigations or those of his students and assistants. This personal contact gives him opportunity for many suggestive hints as to the limitations of our knowledge that will doubtless prove very stimulating and fertile of further investigations. Naturally one turns first to those topics which the author has himself illuminated, but does not find these greatly overbalancing others of like importance. Certainly the most important literature has been well digested, and though, as the author himself fears, there may be oversights in spite of the best intention, these are not striking nor will they be apparent except to the investigator of special problems. Abundant footnote references lead to the original sources.

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[2] PFEFFER, W., Pflanzenphysiologie, ein Handbuch der Lehre vom Stoffwechsel und Kraftwechsel in der Pflanze. Zweite völlig umgearbeitete Auflage. Erster Band: Stoffwechsel. 8vo., pp. x + 620, figs. 70. Leipzig: Wilhelm Engelmann. 1897. *M* 20. (Bound, *M* 23).

One of the most noticeable advances is the recognition of the necessity of a name for the formation of carbohydrates; accordingly we find as a subhead *Photosynthetische Assimilation* contrasted with the rare *Chemosynthetische Assimilation.* Nothing can be said in approval of this phrase, which embodies all the old misusage, except that it seems to be a step toward the abandonment of a misuse of the term assimilation. The section on the manufacture of nitrogenous foods is also greatly improved and extended, now including a discussion of the fixation of free nitrogen by Leguminosae.

Excellent and useful as the work is, it must be said that there are several things which detract seriously from its value. Perhaps they need to be specified all the more since they were equally marked in the first edition and ought to have been corrected in this. Though the book is not intended for beginners, we cannot think that the presentation of the subject is a matter of indifference. Pfeffer's presentation is radically bad. In the first place, his style is so peculiar and involved that it is repellent to the highest degree, and English students who read German with ease will be constantly irritated by the recurrence of uncouth and un-Germanic words and phrases. In the second place, there is a total lack of logical precision of statement, accompanied by much repetition and verbosity. These two faults are aggravated by the want of suitable paragraphing, with titles, so that in parts page after page runs without a break to indicate where a given topic may be found. And when, after search, it is found, the chances are that it is only partially discussed, while the author recurs to it in another place.

Is it to become necessary for scientific men to return to the practice of ages agone, and call in the rhetorician when writing is to be done? Certainly the ancients had the advantage of some of us moderns in recognizing the fact that they needed professional aid in presenting their ideas. Not a few recent books would have been the better for thorough editing by an adept in the art of expression. With a masterly grasp of the subject, it was the graphic and artistic presentation which won for Sach's *Vorlesungen über Pflanzenphysiologie* an almost unique place in botanical literature. Pfeffer shows extraordinary knowledge of the subject and remarkable fertility in suggestion, but lacks sadly the art of logical and picturesque presentation.

Spite of these defects, which we hope will not prevent translation of this edition (as they did of the first), physiology will be greatly advanced by this valuable work. We shall await the second volume with even greater interest, hoping that it may be completely remodeled, for *Kraftwechsel* needs today a radically different approach and treatment from that which it received in 1881.—C. R. B.

MINOR NOTICES.

Black rot of the cabbage, by Erwin F. Smith, forms Farmers' Bulletin no. 68, recently sent out by the U. S. Department of Agriculture. It is a more popular account of the same study to which attention was called in the January Gazette, with additional field observations and rules for preventing.—J. C. A.

The Division of Botany of the United States Department of Agriculture has issued a bulletin describing the camphor tree, its uses, conditions of successful cultivation, a map showing the area of the United States where it might be grown, together with some information as to the commercial outlook for camphor.—C. R. B.

Professor M. A. Brannon, of the State University, has published a report on the grasses and forage plants of North Dakota. The field work was begun under a commission from the Division of Agrostology of the U. S. Department of Agriculture. The report contains valuable notes concerning distribution, nature of soil, etc.—J. M. C.

The movements of plants was the subject of a lecture by Professor D. T. MacDougal, of the University of Minnesota, before the Institute of Jamaica, given in June last, while on a visit to the island in the interests of the proposed tropical laboratory. It is printed in the *Bulletin of the Bot. Department, Jamaica*, for Oct.-Nov., and has been distributed separately. It gives a general review of the subject, with illustrations drawn from the common plants of the island.—J. C. A.

Mr. N. A. Cobb, of the Department of Agriculture, New South Wales, sends us his "Letters on the diseases of plants," a pamphlet of 54 pages issued by the Department at Sydney. It is a compilation of letters written in answer to correspondents who have requested information from the department regarding various plant diseases. The information is put in a popular yet accurate way, and the illustrations, to the number of one hundred, are excellent. The writer shows himself well in touch with the extensive work of this kind carried on in the United States.—C. R. B.

The seventh contribution from the Botanical Department of the Agricultural College of Iowa is devoted to a list of plants collected in the

District of Cienfuegos, Province of Santa Clara, Cuba, in 1895–6, by Robert Combs. The flora of Cuba in general is discussed, the statement being made that it is "interesting, not only for its great number of endemic types, but also for the striking characters of those types, their occurrence, distribution, and economic uses." The flora very closely resembles that of Central and South America, and is said to differ more from that of adjacent Florida, than does the latter from the flora of Canada. The catalogue is a very full one, and is accompanied by ten well-prepared plates.—J. M. C.

THE NEW *Journal of Applied Microscopy*, announced by the Bausch and Lomb Optical Company, has made its appearance. It is devoted to microscopical instruments and technique viewed from a practical standpoint. If the standard set by the first number is maintained the new journal will prove very useful to teachers of botany and zoology, and microscopists in general. Besides many suggestions regarding the use of lenses and other apparatus, this number contains valuable directions for the study of the myxamœbæ and plasmodia of the Mycetozoa. Methods of more direct interest to zoologists are also contained in this initial number.—C. J. C.

THE MOST RECENT *Bulletin*[3] from the Iowa State University contains an account of the ferns collected by B. Shimek on the Nicaragua botanical expedition of the University in 1893. The report is exceedingly well done, the greatest care apparently having been taken in the determinations and in the organization of all available data. The author has done well to append to each genus a list of all species reported from Nicaragua not included in his collection. Twenty remarkably good plates accompany the contribution. The total number of species and varieties reported from Nicaragua is 198, representing 39 genera, of which 126 species and 32 genera were collected by Mr. Shimek. The report adds one new species, seven new to Central America, and thirty-seven new to Nicaragua. It seems that of the species collected by Mr. Shimek eighty-one are terrestrial, forty-one are epiphytic, and two have adopted both habits.—J. M. C.

THE REVISION of the genera of Hepaticæ is progressing in the hands of various American students with considerable rapidity. In addition to the general treatment of the whole group by Dr. Underwood in the Systematic Botany of North America, which may be expected shortly, Mr. Alex. W. Evans has recently given us a full account of the North American species of Frullania, accompanied by fifteen plates.[4] With the exception of Jungermania, Frullania is the richest in species of all our hepatic genera. Dr. Evans recognizes twenty-two species, of which two are imperfectly known. T drawings, illustrating the species, made by the author, are admirable in th clearness and fullness. The following changes from the names in Gra Manual are noted: *F. Pennsylvanica* has already been transferred to Jul *F. saxicola* is referred to *F. Virginica*, and *F. fragilifolia* Aust. (not Tay *F. Selwyniana* Pearson; *F. æolotis* is *F. riparia* Hampe; and *F. dilata* described as *F. Brittoniæ*, n. sp.

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[3] Bull. from Lab. Nat. Hist. 4:95–224. 1897.

[4] EVANS, ALEXANDER W.—A revision of the North American species of Frullania, a genus of Hepaticæ. Transactions of the Connecticut Academy of Sciences 10:1–39. *pl. 15.* May 1897.

Mr. Marshall A. Howe has lately examined the species of Pore belonging to North America. Schiffner in Engler and Prantl's *Pflanzenfami* rejected the name Madotheca, which Dumortier adopted for this genus, a also considered Porella a *nomen nudum* of Linnæus. But Howe, backed the recent examination by Underwood of the Dillenian plant at Oxford, f lows Lindberg and others in the use of Porella. He recognizes eight spec The five of Gray's Manual are pretty well changed. *P. Sullivantii* is refer to *P. pinnata*; *P. Thuja* to *P. platyphylla*; while *P. dentata* becomes *rivularis* (Nees) Trevis.—C. R. B.

AFTER LONG interruption the *Contributions* fron the Botanical Laborat of the University of Pennsylvania have been resumed by the publicat no. 3 of vol. I. It contains three papers: A chemico-physiological stud *Spirogyra nitida*, by Mary E. Pennington, Ph.D.; On the structure and p lination of the flowers of *Eupatorium ageratoides* and *E. cælestinum*, Laura B. Cross, Ph.D.; and Contributions to the life-history of *Amphicar* *monoica*, by Adeline F. Schively, Ph.D. The first of these papers is par larly meritorious. Not only does it bring out some interesting new fa which are connected with those already known, but it shows ingenuity in devising and execution of the experiments. Particularly useful to oth workers will be the carefully described set of color screens, by means which monochromatic light may be secured. They seem a decided impr ment on other formulæ. Perhaps the most interesting conclusion is that t influence of monochromatic light on the growth of Spirogyra is due ma to the effect of the particular light on diastase.

The second paper is very brief. By her experiments the author is to the conclusion that self-pollination in the two species of Eupatorium very rare indeed, and that even when it does occur the fruits are of we germinating capacity. The visits of insects, however, insure a large p centage of good fruits.

The third paper is a very detailed account of the morphology and ph ology of Amphicarpæa; a useful catalogue of facts, but not correlated w others by the author. One fact of interest is that this plant has very ra circumnutation movements, completing a circuit in 51 minutes.—C. R. B

[5] HOWE, MARSHALL A.—The North American species of Porella. Bullet the Torrey Botanical Club 24:512–527. N 1897.

NOTES FOR STUDENTS.

In a paper by C. Warnstorf, entitled "Beiträge zur Kenntniss exotischer Sphagna,"[6] in the midst of a large number of new species from Brazil, Australasia, South Africa and Reunion, two new Sphagna subsecunda from the United States are described, and several new stations given for species already known. One of the new ones is *S. Langloisi*, from St. Martinsville Louisiana, and the other *S. xerophilum*, from Alabama.—C. R. B.

Mr. Charles H. Peck's annual report for the year 1895, as state botanist of New York, was recently issued. Beside the bare list of additions to the herbarium and names of contributors, it contains observations upon fifty species of plants not before reported for the state of New York, of which seventeen species, all fungi, are described as new to science. There are also remarks on thirty-one other species, over half being flowering plants; seven species of the fungi have new varieties described. The New York species of the genus Collybia, numbering thirty-four, are monographed, with revised descriptions, extended notes and carefully prepared keys, together with a key to the twenty extra-limital species. Ten species of edible fungi, and one unwholesome species, are described and illustrated with colored quarto plates, forming a supplement to the notable issue of the previous year. The quarto form fits in badly with the octavo form previously adopted, but as the plates they are in quarto, they can be once folded when bound, and by this simple means the whole series kept uniformly in octavo.—J. C. A.

Items of taxonomic interest are as follows: John K. Small[7] has described some additional new species (Vicia, Samolus, Limonium, Eupatorium, Chrysopsis, Silphium) from the South Atlantic states. Edward L. Greene[8] has described some new Compositæ (Coleocanthus, Erigeron, Machæranthera, Gaillardia) from New Mexico and Arizona. Eugene P. Bicknell has described a new species of Asarum[9] heretofore confounded with *A. Canadense*, and two new species of Sanicula.[10] Mrs. E. G. Britton[11] has published a revision of the North American species of Ophioglossum, recognizing eight species, two of which are new. *O. vulgatum* of the southwest is *O. Engelmannii* Prantl. T. H. Kearney[12] has published a very interesting series of plants from eastern Tennessee, several of which are new (Cimicifuga, Stylosanthes, Scutellaria, Xanthium). Miss Alice Eastwood[13] has begun a series of papers entitled "Studies in the herbarium and the field," the first number containing new forms of Œnothera and Bigelovia, two new spurless forms of

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[6] Hedgwigia, **36**: 145–176. 1897.

[7] Bull. Torr. Bot. Club **24**: 490–493. 1897.

[8] *Ibid.* 511–512.

[9] *Ibid.* 528–536.

[10] *Ibid.* 577–582.

[11] *Ibid.* 545–559.

[12] *Ibid.* 560–575.

[13] Proc. Cal. Acad. Sci. III. **1**: 71–88. 1897.

Aquilegia, new species of Iris, Montia, and Newberrya, and three new spe of Arctostaphylos. The Royal Botanic Gardens of Trinidad has begun publication[14] of descriptions of the ferns of the British West Indies Guiana, by G. S. Jenman, government botanist of the Colony of B Guiana. The first fascicle contains Hymenophyllum and Trichomanes former represented by twenty-nine species (two of which are new), the la by forty-two species (one of which is new). Mrs. Katherine Brandegee begun a valuable series of papers entitled "Notes on Cacteæ." The number discusses the forms of Lower California, concerning which the au is specially competent to speak. The race for new African species is be ing more interesting daily, and most of the taxonomic centers of Europe competitors. Wood and Evans[16] have published a second decade of "N Natal plants;" the work directed by Engler has resulted in a fascicle o papers in the most recent number of the *Jahrbücher*,[17] the families pres being Sapindaceæ (Gilg), Acanthaceæ (Lindau), Gramineæ, Cyperaceæ Commelinaceæ (Schumann), Compositæ (Hoffmann): while Durand Wildeman[18] have published the first fascicle of a list of Congo plants, in which many new species are described. Hallier[19] has begun the publica of a revision of Convolvulaceæ, the first paper containing Calonyctio of whose six species belong to the American flora, having been refer usually to Ipomœa and Convolvulus. Huth[20] has published a descripti of Japanese Ranunculaceæ, in which seventeen genera are represented, which have representives in America. Eighty-three species are enumer the largest genera being Ranunculus (13 species), Clematis (12), Thal (12), Anemone (11), Coptis (6), and Trollius (6). Glatfelter[21] has discus *Salix longipes* and its relation to *S. nigra*.—J. M. C.

THE SUBJECT of contractile roots is assuming larger and more def proportions. A. Rimpach[22] has summarized the subject, finding that sev species, representing twenty families of monocotyls and dicotyls, are rec as possessing contractile roots. The power has been observed only in baceous, and chiefly in geophilous plants. The greatest amount of cont tion is said to be 70 per cent., and the families most frequently represe are the Liliaceæ, Iridaceæ, Amaryllidaceæ, and Araceæ.—J. M. C.

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[14] Bull. Misc. Information 4: 1–32. 1898.

[15] Erythea 5: 111–123. 1897.

[16] Jour. Bot. 35: 487–490. 1897.

[17] Bot. Jahrb. 24: 305–464. 1897.

[18] Bull. Soc. Roy. Bot. Belgique 36: 47–97. 1897.

[19] Bull. de l'Herb. Boiss. 5: 1021–1052. 1897. [20] Loc. cit. 1053–1090.

[21] Rep. Mo. Bot. Gard. 9: 1–9. 1897.

[22] Beitr. z. wiss. Bot. (Fünfstück) 2: 1–28. 1897. Cf. Jour. Roy. Micr. Soc. 1897, p. 551.

THE EMBRYOGENY of Triticum has been investigated by M. Koernicke.[23] He finds the usual axial row of four mother cells in the ovule, the lowest of which develops the macrospore. As already well known among Gramineæ, the antipodals are most apt to develop a more or less extensive tissue, which the author considers to be accomplished by direct division. The chromosomes were found to be usually sixteen in number in the vegetative cells of the inflorescence, eight in the mother cells of both microspores and macrospores, and sixteen again in the oospore.—J. M. C.

DAVID M. MOTTIER has recently published a paper[24] on the behavior of the nuclei in the development of the embryo sac and the phenomena of fertilization. The plants studied were *Lilium Martagon*, *L. candidum*, *L. umbellatum*, *Helleborus foetidus*, and *Podophyllum peltatum*, the same plants as those used by the author in his previous paper[25] upon a related subject. The methods were also the same.

At an early stage in the development of the primary nucleus of the embryo sac a remarkable differentiation takes place in the cytoplasm. Numerous kinoplasmic threads appear which may form a felt around the nucleus, or may take the form of strands radiating from the nucleus, or may even be separated from the nucleus and form a bunch in one end of the cell. Later these threads disappear, and the cytoplasm seems to have a uniform structure. The spirem and segmentation stages take place just as in the author's description of pollen mother cells. He still regards synapsis as an artefact.

He refers to the only previous description of spindle formation in plants, that of Guignard,[26] who says the spindle takes its origin from two directive spheres. Since Mottier declares that there are no directive spheres in pollen mother cells or embryo sacs he necessarily looks for some other method of spindle formation. He finds kinoplasmic fibers variously arranged which press into the nuclear cavity as the nuclear membrane disappears. Some of these fibers become fastened to the chromosomes and soon form a multipolar spindle which quickly becomes bipolar. The chromosomes are V-shaped, with the point toward the pole. The first division in the embryo sac is heterotypic, and agrees fully with that already described in pollen mother cells.

The second division follows without a complete resting stage. The spindle formation is the same as in the first division, but not so easily studied. Mottier was surprised to find that the segmentation of the spirem came after the spindle was fully formed. The same phenomenon was described b fessor Coulter[27] after Mottier's article was written, but before it had reache the Chicago laboratory.

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[23] Verhandl. Naturhist. Ver. Preussen Rheinl. 53: 149–185. 1896. Cf. Jour. Roy. Micr. Soc. Dec. 1897, p. 553.

[24] Ueber das Verhalten der Kerne bei der Entwickelung des Embryosacks und die Vorgange bei der Befruchtung. Jahrb. wiss. bot. 31: 125–158. 1897.

[25] Beiträge zur Kenntniss der Kerntheilung in den Pollenmutterzellen einiger Dikotylen und Monokotylen. *Ibid.* 30: 169–204. 1896.

[26] Ann. Sci. Nat. Bot. VII. 14: 163–296. 1891.

The third division is like the second rather than the first. The lowe antipodal spindle is often abnormal, but the division is not considered a tic as described by Miss Sargant. The polar nuclei, unlike the syne and the egg, are not surrounded by a "Hautschicht," that of the egg ratus being formed from the connecting fibers. At the time of fusion the sex nuclei are in the resting stage. The membrane between the disappears, and after the fusion it is impossible to distinguish the male female portion of the new nucleus.

After describing nuclear division in vegetative cells, the vegetative sion is compared with the heterotypic, the structure of the resting nu being the same in both. In both there is a longitudinal fission of the nu thread. In the heterotypic there is often a synapsis due to reagents. chromosome segments form rings or ellipses, or lie over each other be they are arranged in the nuclear plate; and in separating, the V-sha chromosomes have the spindle fibers attached at the apex, while in the ve tative form the spindle fibers are attached at or near the end of the chr some.

Mottier finds that while a reduction in the number of chromosomes ta place in the primary embryo sac nucleus, there is no so-called redu division. This does not agree with his work on pollen mother cells, and will consequently reinvestigate that subject.—C. J. C.

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[27] Bot. Gaz. **23**: 416. *pl. 32, figs. 10, 12.* 1897.

NEWS.

Gebrüder Borntraeger have issued a neat pamphlet containing a full description of their numerous scientific publications.

Professor Dr. Gregor Kraus has been called to the professorship of botany in the University of Würzburg, as successor to the late Julius von Sachs.

The American Book Company announces the early appearance of "A laboratory manual in practical botany," by Charles H. Clark, Principal of Windsor Hall, Waban, Mass.

Arrangements have been made for an English translation of Pfeffer's "Physiology," by Dr. Ewart, to be published by the Clarendon Press. A French translation is also to be published in Paris.

Mr. John W. Harshberger has published an ecological sketch of the vegetation of the Yellowstone hot springs in the *American Journal of Pharmacy* for December 1897.

The issue of *Photogravures of American Fungi*, by C. G. Lloyd, has reached number 22. The last two numbers show fine reproductions of *Lepiota Americana* Pk., and *Calvatia cælata* Bull.

Dr. Gyula Istvanffi, chief of the botanical section of the Hungarian National Museum at Budapest, and privat-docent in the University, has been called to the professorship of botany in the University of Klausenburg.

A biographical sketch of the late Dr. J. E. Humphrey is published in *Johns Hopkins University Circular* 17: no. 132, Nov. 1897, prepared by J. S. Kingsley and B. W. Barton. A bibliography is appended, containing thirty titles, extending from 1886 to 1896.

F. Kempe, a wholesale merchant of Stockholm, has established a fund of 150,000 kroner (about $40,000) for the foundation of a professorship and an institute of plant ecology in the University of Upsala. Dr. A. N. Lundström, docent, has been called to the chair.

We omitted to make announcement, at the proper time, of the death of Henry N. Bolander, whose collections on the Pacific coast have done so much to make known the flora of that region. He had been a resident of Portland, Oregon, for some years, where he died August 28, 1897.

DR. DOMENICO SACCARDO, of the Royal Botanical Garden at Padua, h just issued the first two centuries of a *Mycotheca Italica, seu Fungi It* *exsiccati*, which is said to contain some new species and many forms n hitherto published in exsiccati. The price is *fr.* 15 per century.

THERE HAS JUST COME to us a paper by Professor Thomas C. Porter “The Pennsylvania-German in the field of the natural sciences.” It conta most interesting accounts of several botanical worthies, together with th portraits. Among these we note Mühlenberg, Schweinitz, Wolle, and Garb

AT THE thirteenth annual meeting of the Indiana Academy of Scie held at Indianapolis December 29 and 30, 1897, fifteen botanical papers we presented out of a total of eighty. The following officers were elected 1898: *President,* C. A. Waldo, Purdue University; *Vice-President,* C Eigenmann, Indiana University; *Secretary,* John S. Wright, Indianap The volume of proceedings is a public document, a limited number be printed by the state, the copies being distributed by the state librarian un the direction of the Academy.

AN EXPEDITION for the collection of all classes of flowering and cry gamous plants is being arranged, for the season of 1898, to explore the Plata and San Juan mountains of southeastern Colorado. Specimens wil secured to illustrate, so far as possible, not only the species of the region, also the range of variation due to environment, such as climate, altitude, a exposure. Sets of specimens will be sold at $7 per hundred, of either complete series, or particular groups, as preferred. Prospective purchase can obtain information of Mr. Carl F. Baker, Auburn, Alabama.

WITH THE NEW YEAR the *Pharmaceutical Review* changes its form fr quarto to large octavo. It also announces that more space will be devoted the monthly review of pharmaceutical literature. To accommodate the la amount of original matter which has increasingly crowded out these review new journal, *Pharmaceutical Archives*, will be established under the edi ship of Dr. Edward Kremers, of the University of Wisconsin. The new fo of the *Review* is certainly more convenient than the old one, with its dou columned pages, which necessitated the annoying repagination of all artic reprinted. We congratulate the editors on the improvement.

A BOTANICAL CLUB was organized in St. Louis last December, to b known as the “Engelmann Botanical Club.” It is planned to have reg bimonthly meetings for the reading of papers and reviews, and to have fie days in the spring. The following officers were elected for 1898: *Presid* William Trelease; *Vice-Presidents,* G. W. Lettermann and Henry Egge *Secretary,* Hermann von Schrenk. At the meeting of January 13, L. Pammel read a paper on the flora of Iowa; J. B. S. Norton discussed th coloring matter of some North American Boraginaceæ, and H. von Schrenk spoke of *Merulius lacrymans* and its occurrence in the cypress marshes of northern Mississippi.

IN THE REPORT of the botanist of the Department of Agriculture for 1897 the work of the year is considered under the following heads: field experiments with seeds, investigation of new crops, national herbarium, economic herbarium, natural resources, weeds, poisonous plants, testing seeds distributed by the department, seed investigation, support of the pure seed movement, American medicinal flora. This gives some idea concerning the subjects which have been interesting the division. The needs for the ensuing year are said to be a building, permanent trial grounds, and an additional assistant to investigate the subject of "natural agricultural belts or areas as indicated by the natural vegetation."

ONE of the most vigorous of American scientific societies is the American Society of Naturalists. Founded in 1883, meeting annually between Christmas and New Years in some one of the eastern cities, and aiming to promote those interests which naturalists have in common, it has not only grown itself, but it has attracted to meet with it several other leading scientific societies. The annual meetings of these affiliated societies have become of rapidly increasing importance, until at present they are second to none in this country in influence and value. For two or three years past associations of animal morphologists, animal physiologists, animal anatomists, psychologists, and finally anthropologists have met to hold, along with sessions of their own, others in common with co-workers in related fields. In this development botanists have taken no part. A few have been accustomed to attend the meetings of the central society, the Naturalists, but as the special societies have gradually attracted the more special biological subjects into themselves, these meetings have become of less use to them. At the same time many botanists have felt that a most valuable opportunity is being wasted by their failure to meet along with these vigorous organizations, and, moreover, that the science and profession both suffer by their silence when the related sciences are being brought so conspicuously and favorably into notice. This feeling expressed itself at the Philadelphia meeting in 1895 in a meeting of the botanists present, and the appointment of a committee, with the late Dr. J. E. Humphrey as chairman, to investigate the question of the desirability of forming a botanical organization to meet annually with the other scientific societies. By correspondence during the ensuing year the committee became convinced that there was no call for a new botanical society of general scope, and it became a question of a society of special character and limited range of membership, or none. This report was made to a meeting of botanists present at the Boston meeting of the affiliated societies, December 30, 1896, and those present, after full discussion, constituted themselves a "Committee

on the organization of a society for vegetable morphology and physio
meet annually with the American Society of Naturalists." Those pre
were Messrs. W. G. Farlow, W. P. Wilson, J. M. Macfarlane, Miss E
Gregory, B. L. Robinson, R. Thaxter, H. M. Richards, J. M. Greenma
F. Ganong. W. F. Ganong was appointed secretary. During the
eleven other botanists were invited to join the committee, and acce
They were Messrs. G. L. Goodale, Miss Clara E. Cummings, D. P. Penha
G. E. Stone, W. C. Sturgis, J. E. Humphrey, B. T. Galloway, E. F. S
L. H. Bailey, G. F. Atkinson, E. A. Burt. During the year a scientific
ing was arranged for, which was held along with the affiliated societie
Ithaca, December 28, 1897, and which is fully reported in this number
GAZETTE. At a business session on December 27th, the Committee orga
itself into a "Society for the promotion of research in plant morph
and physiology, with the general understanding that it shall meet wit
American Society of Naturalists," and adopted as a name, "Society for
morphology and physiology." Rules for the government of the society
drawn up and the following new members were elected: V. M. Spalding
Webber, W. T. Swingle, W. W. Rowlee, J. W. Harshberger, D. G. Fa
R. A. Harper, A. F. Woods, A. J. Pieters, G. H. Hicks, H. C. Porter.
Harriet L. Merrow, Theo. Holm. Officers for the ensuing year were el
as follows: *President*, W. G. Farlow; *Vice-Presidents*, J. M. Macfarlane,
Atkinson; *Secretary-Treasurer*, W. F. Ganong. Membership is of cour
limited geographically, but it is expected mainly to be drawn from those
live near enough to the places of meeting of the Society of Natural
enable them to attend regularly.

This description of its origin will show that the new society is not
least intended to interfere in any way with the work of the older soc
but it is meant to fill a place which they do not occupy. It seems pla
founders that botanical activity in this country has become great eno
need all of these societies for its expression, and specialized enough t
special societies devoted to particular branches of it, a condition whic
realized some time ago in the sister science of zoology.—W. F. GANON

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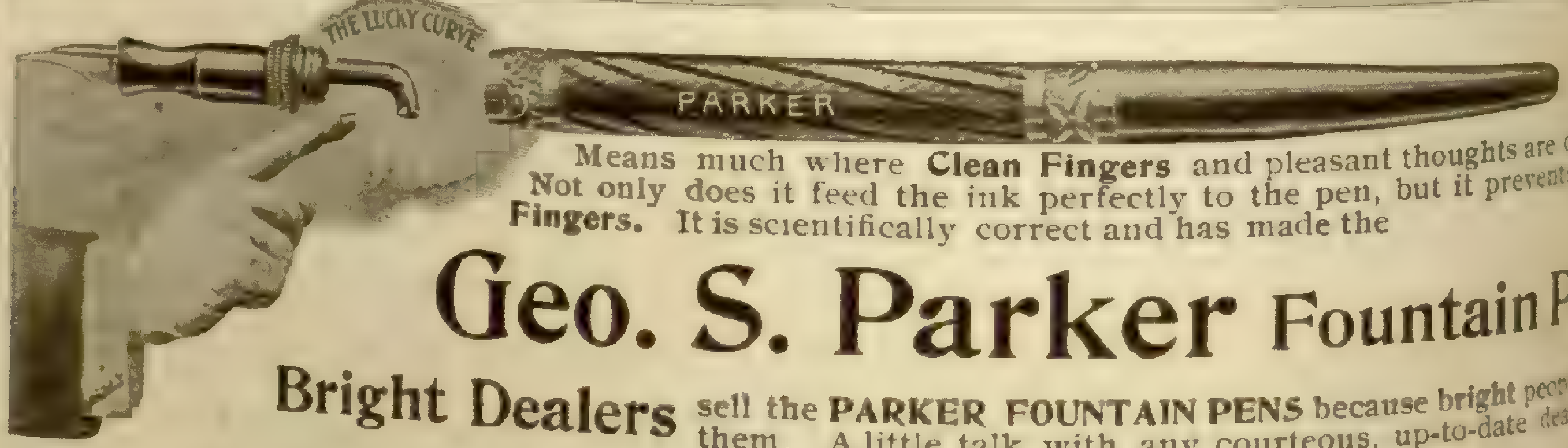

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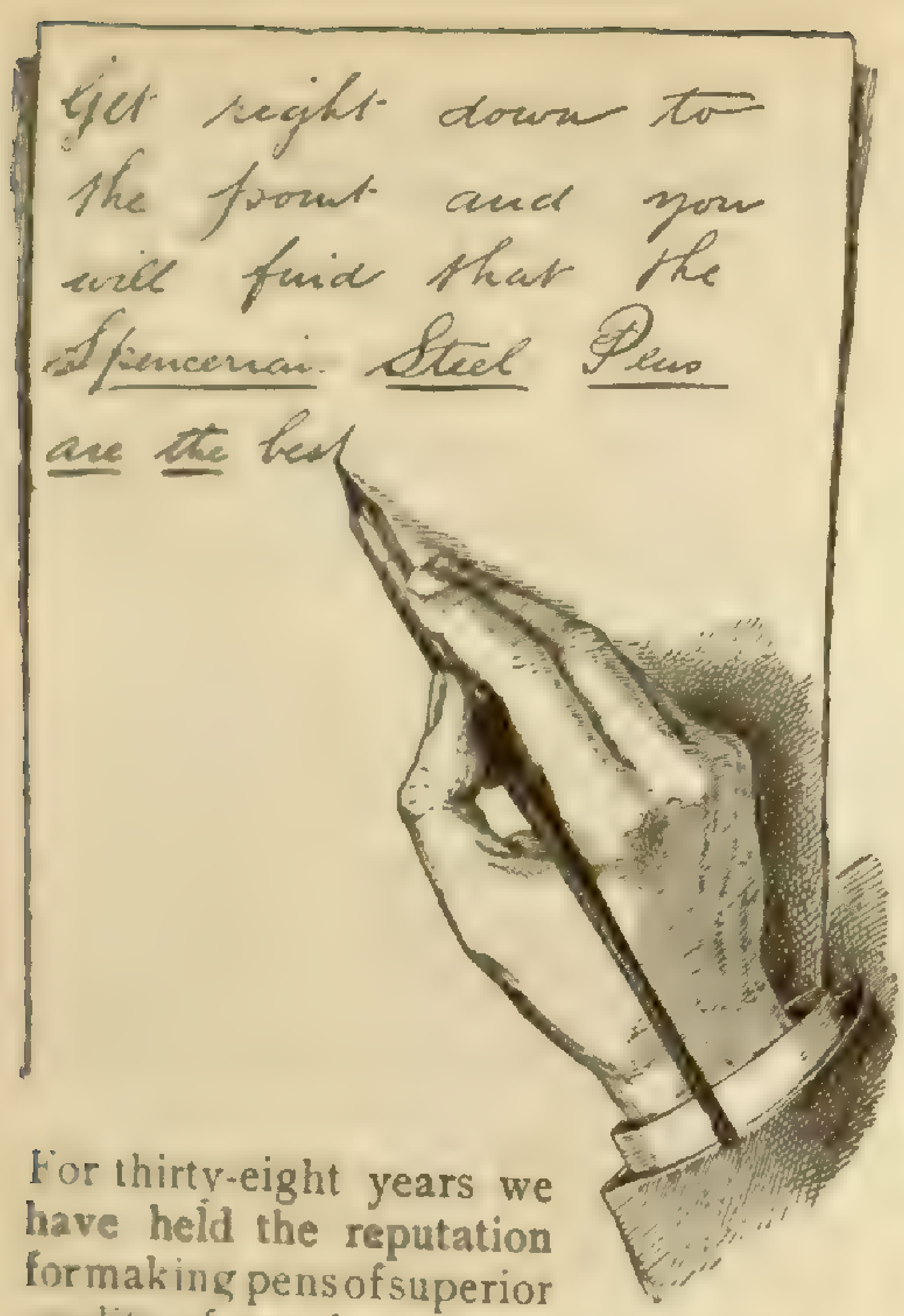
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It is easy to realize that if no obstacles stood in the way of the physical and mental progress of mankind, a few years would show developments so rapid, that it would be hard to keep pace with them. So nature provides a way to kill off the surplus and give those who insist upon winning, some work before they earn their spurs. Most powerful animating motives dominate men, that by seeming mesmeric power, direct them to use elements, well-known factors for physical and mental destruction. Among these, we have whisky, tobacco, coffee.

The healthy ones smile and say, "They never hurt me," and go along in a helpless fashion much like hypnotic subjects, until sudden collapse occurs and they wake to find paralysis, heart failure, Bright's disease or some form of nervous climax has settled itself upon the body, and become a most undesirable visitor. That a man should yield himself to the machinations of this tearing down law, and enter a game where the loss is sure, with an absolute impossibility of winning, is worthy of note. This seems nature's way to keep down the crowd and allow room for the few determined ones to win out.

It requires no argument or special mental ability, to teach the trainer of a fine race horse, that if he expects his horse to win in the sharp competition in the speed ring, the physical body of the horse must be properly cared for, by good food, drink, fresh air and exercise.

No care would be spared to prevent such a horse from taking into his system, any sort of drug or disintegrating substance that would break down his powers. On the other hand, the wonderful racing machine found in the American citizen of today, is fed in a haphazard fashion, dosed many times a day with a powerful drug called tobacco, and at meals dosed with another powerful drug, called coffee.

These drugs have effects thoroughly well known to all scientific men, and these effects are to alternately stimulate and depress the heart's action, interfere with the digestion of food and slowly break down the delicate gray matter that fills the nerve centers in the entire body.

Cruelly robbed of his powers, the man who presses forward to gain prominence or even competence, many times falls by the wayside, and if by fortune, his constitution is strong enough to carry him along until competence is gained, too often he is unable to enjoy the fruits of his labors, because the highly valued, priceless possession of health has flown.

We all realize, perhaps, that there are some men in the world who could be spared and might perhaps as well be slowly killed off with whisky, tobacco and coffee, as it were, but it is painful experience to those who look with honest pride upon the magnificent work of many of our Americans, to note the failing of their powers caused by the administration of drugs, under this law of compensation. It is true we should allow each individual the liberty of selecting his own pathway, whether it be up or down, providing it does not interfere with the rights of others, but any man or woman who has any sense of pride in the advancement of the race experiences a feeling of deep regret at the destruction of brilliant possibilities.

Each individual can, if he will, strip off the powerful impediments, that greatly lessen the powers, even when they do not totally destroy the human organism. Many persons frequently find as great a task in breaking the mesmeric spell of the lesser drugs such as tobacco and coffee, as they do in surrounding whisky, and it is quite commonly remarked, that the lesser drugs really do a greater volume of injury, from the fact that their powers are more hidden.

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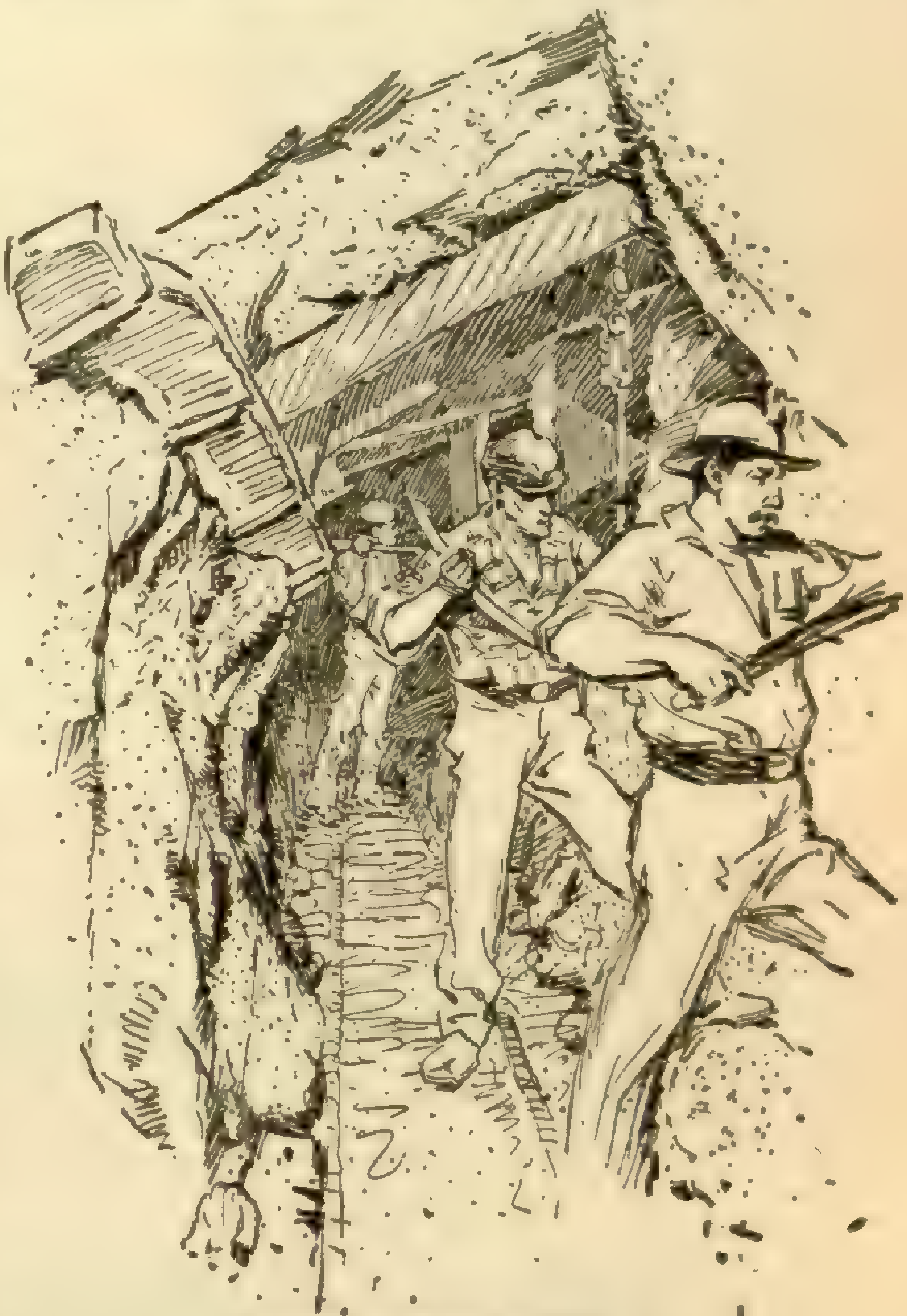

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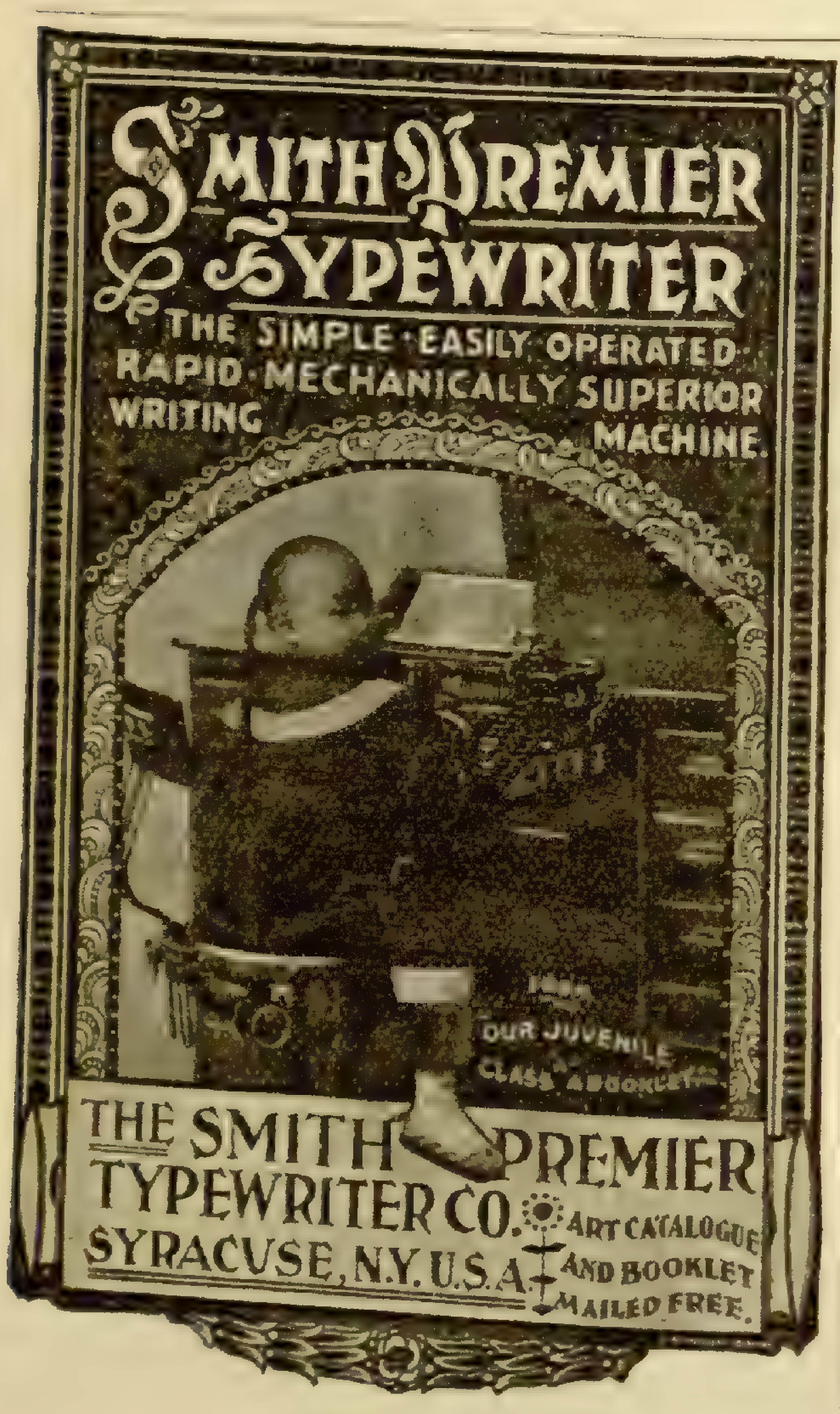

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VOLUME XXV NUMBER 3

BOTANICAL GAZETTE

MARCH 1898

UNDESCRIBED PLANTS FROM GUATEMALA AND OTHER CENTRAL AMERICAN REPUBLICS. XX.

JOHN DONNELL SMITH.

(WITH PLATE XII)

Theobroma simiarum Donn. Sm.—Folia obovato-oblonga cuspidata ad basin cordatam 3-nervia dentato-repanda supra glabra subtus subcanescentia et in nervatione fusco-pilosa. Inflorescentia e trunco prorumpens fasciculata intricato-ramosa multiflora. Ligulae jam in aestivatione reflexae cucullo vix bis longiores obovatae retusae in unguem gracilem attenuatae staminodiis obovato-lanceolatis paulo breviores dimidio angustiores. Stamina triantherifera. Fructus elliptico-cylindraceus coriaceo-cartilagineus exangulatus exrugosus.

A lofty tree with spreading branches, younger parts and inflorescence tomentose. Stipules linear-lanceolate, plurinerved, about 2^{cm} long. Leaves coriaceous, 3–$4^{dm} \times 14$–19^{cm}, strongly reticulated, midrib and lateral nerves prominent beneath; petioles stout, about 12^{mm} long. Cymes subsessile, axes woody, pedicels bibracteolate in middle. Calyx tomentose, partite nearly to base; segments reflexed, 10×6^{mm}, acute, furnished within at base with yellow and minutely oblong glands. *Cuculli* glabrous, oval, 6^{mm} long, 5-nerved; *ligulae* glabrous, with claw 5^{mm} long added 10^{mm} long, at rounded apex 4^{mm} broad. Staminal tube naked, 2^{mm} high, equaling the free part of filaments; staminodes erect, glabrous, exunguiculate, 13^{mm} long, at base 2^{mm} broad. Styles distinct nearly to base, twice longer than globose and tomentose ovary. Fruit 24–26^{cm} long, 8.5–9^{cm} in diameter, rounded at apex, more obtuse at base, fusco-farinose, surface uniformly even; seeds about 45, compressed-globose, about 2cm in diameter.— Differs from other many-flowered species by conspicuously petaloid staminodes, and from all congeners by the elongated fruit, of which the surface is neither angled, ribbed nor excavate.— Popular name *Cacao de Mono.*

Hacienda de La Concepcion, Llanuras de Santa Clara, Costa Rica, alt. 200m, Feb. 1896, *Donn. Sm.*, no. 6457 Pl. Guat. etc., qu. ed. Donn. Sm.— Térraba, C. R., alt. 260m, Feb. 1891, *Pittier & Tonduz*, no. 3925 herb. nat. C. R.— Forests of Boruca, C. R., alt. 466m, Mch. 1892, *Tonduz*, no. 6852 herb. nat. C. R.— Turrialba, alt. 570m, C. R., Nov. 1893, *Tonduz*, no. 8575 herb. nat. C. R.— Santa Clara, C. R., Sept. 1896, *Cooper*, no. 10244 herb. nat. C. R.

Sambucus oreopola Donn. Sm.— Foliola 9–11 maxima opaca supra præter nervos furfuraceos glabrescentia subtus pube cinerascente pallidiora, lateralia lanceolata sensim et acutissime elongata ad basin rotundata, terminale e medio utrinque attenuatum. Cyma decomposita 5-radiata.

Apparently arborescent. Stipules subulate, acute, 4–5mm long. Leaves with petiole 1dm long and dilated at base added, 3–4dm long; leaflets exstipulate, the younger elliptical-lanceolate and acuminate at each end, the fully grown ones 16–19 × 4–5cm, the lower ones with a petiole 5–8mm long, the upper sessile, the uppermost pair occasionally decurrent-adnate, terminal petiolule 1–2cm long; lateral nerves about 6–8 to the side, the lower ones short, the upper long-ascending at a narrow angle with midrib, veins subobsolete on upper surface; the whole margin incurved-mucronulate-serrate. Cyme corymbiform, glabrous, 2–5dm long, 3.5dm broad; flowers 5-merous, 5–6mm in diam. Tube of calyx semiglobose, 1mm high, sulcate, little longer than the ovate lobes. Corolla within sparsely pilose. Berries not present.— A subalpine species differing little from *S. Canadensis* Linn. except by form, size and indument of leaves.

Forests of Rancho Flores, Volcán Barba, C. R., alt. 2043m, Feb. 1890, *Tonduz*, no. 2107 herb. nat. C. R.— Volcán Irazú, C. R., alt. 2000m, July 1891, *Tonduz*, no. 4223 herb. nat. C. R.

Burmeistera microphylla Donn. Sm.— Glabra. Folia minima internodiis longiora ovato-elliptica utrinque acuminata succulenta, margine glandulis paucis obscure crenato, nervis venisque supra impressis subtus immersis. Pedunculi nutantes foliis vix longiores. Calycis tubus parvus lobis oblongis subbrevior. Corollae tubus anguste elongatus calyce 3-plo longior lacinias super-

riores bis superans. Columna staminea tubo triente longior, antheris inferioribus apice aureo-barbatis. Bacca globosa.

A small shrub, apparently epiphytal. Leaves 18–20 × 3–11^{mm}, yellowish beneath; nerves three to the side, reticulately anastomosing; petioles 3^{mm} long. Peduncles axillary. Tube of calyx turbinate, 1.5^{mm} high, lobes 2^{mm} long. Corolla virescent, tube 1.5^{cm} long, 2^{mm} in diameter, two superior segments 8^{mm} long, the lateral 6^{mm} long, the inferior 4^{mm} long. Staminal column adnate a little above base of tube, 2^{cm} long; superior anthers sprinkled with golden hairs, 3^{mm} long, a half longer than the others. Lobes of stigma 1^{mm} in diameter. Berry 6^{mm} in diameter, crowned with accrescent lobes of calyx.

La Palma, Costa Rica, alt. 1520^{m}, Nov. 1897, *Wercklé*, no. 11600 herb. nat. C. R.

Burmeistera tenuiflora Donn. Sm — Folia subintegra oblongo-elliptica contracto-acuminata ad basin acuta, facie inferiore pallida fusco-reticulata ad costam nervos petiolos pubescente. Calycis tubus obconicus 5-costatus in pedunculum sensim attenuatus laciniis linearibus brevior. Corollae tubus tenuis laciniis et calycinis et propriis longior. Columna staminea basi corollae adnata glabra vix exserta, antheris totis imberbibus.

Leaves 6–8 × 2.5–3^{cm}, petioles 6–9^{mm} long. Peduncles exceeding leaves, 5–7^{mm} long. Tube of calyx 7^{mm} long, at top 4^{mm} broad, segments 9–10 × 1^{mm}, their sinuate margin glandular-punctate. Tube of corolla 11^{mm} long, at top 2.5^{mm} broad; segments falcate, broad, canescent and reticulate on face, the superior ones 9 × 4^{mm}, the inferior a third smaller. Staminal column 2.2^{cm} long, anthers 6^{mm} long. Lobes of stigma 2^{mm} in diameter. Berries not seen.

Forests of Alto del Roble, Volcán Barba, C. R., alt. 2000^{m}, May 1888, *Pittier*, no. 19 herb. nat. C. R.

Cavendishia capitulata Donn. Sm.— Glabra. Folia subsessilia parva oblongo-obovata quintuplinervia reticulata, nervis venisque subtus immersis. Inflorescentia axillaris terminalisque sessilis, floribus paucis subcapitatis parvis e bracteis paulo emergentibus, bracteolis geminis oblongis calycem fere obtegentibus membranaceis ciliolatis. Calycis dentes acuti ciliolati. Corolla non nisi glandulis denticulata.

Apparently a small shrub. Leaves 20–25 × 8–9^{mm}, coriaceous, apex obtuse, base acute, margin revolute, petioles 2^{mm} long. Bracts purple, the

exterior ones minute and orbicular, the interior elliptical; the innermost largest, 12×8^{mm}, obtuse. Pedicels 3–4, scarcely 1^{mm} long. Bracteoles 4^{mm} long, obtuse. Calyx 4^{mm} high, base intruded; limb equaling tube, minutely denticulate. Corolla roseate, narrower and paler above, 12^{mm} long, apiculated with dentiform red glands. Genitals equaling corolla. Stamens of equal length; filaments slightly cohering in a tube 2^{mm} high, their free part alternately equaling the tube or almost none; anthers subequal, 2^{mm} long, their tubes alternately 5 or 7^{mm} long. Matured berry not seen.—Nearest to *C. strobilifera* Benth. et Hook.

La Palma, Costa Rica, alt. 1500^{m}, Nov. 1897, *Wercklé*, no. 11565 herb. nat. C. R.

PERNETTYA CILIARIS D. Don, var. **alpina** Donn. Sm.—Ramuli dense setosi. Folia e basi obtusiuscula oblongo-lanceolata subtus setifera. Pedunculi folia aequantes per totam longitudinem bracteosi.

Cerro de La Muerte, C. R., alt. 3100^{m}, Jan. 1897, *Pittier*, no. 10543 herb. nat. C. R.

Ardisia pleurobotrya Donn. Sm.—Folia obverse lanceolato-elliptica superne contracto-acuminata deorsum attenuata integra coriacea immaculata subtus lepidota. Paniculae axillares longe pedunculatae folia subaequantes lepidotae, pedicellis ad apicem ramorum primariorum alternorum umbellatim racemosis. Corollae usque ad duas partes fissae segmenta ovata acuta calycinis vix bis longiora. Antherae subsessiles breves lanceolatae longitudinaliter dehiscentes.

Younger branchlets rufescent, lepidote, internodes very short. Leaves glabrous above, beneath rufescent and densely covered with scales conspicuous under a lens, $8–10 \times 2.5–3^{cm}$, apex obtuse; lateral nerves somewhat remote, prominent only on lower surface; petioles $6–10^{mm}$ long. Panicles from upper axils, peduncles $4–7^{cm}$ long, rhachis $2.5–4^{cm}$ long, primary branches $1–2^{cm}$ long; pedicels chiefly four or five, about 1^{cm} long; lower bracteoles oblanceolate, 8^{mm} long, the upper subulate and minute. Segments of calyx ovate, 2.5^{mm} long, in center lepidote and maculate, margin hyaline and ciliolate. Tube of corolla maculate-punctate, 2^{mm} long, segments 1^{mm} long. Anthers inserted at middle of tube, 2.5^{mm} long. Ovary subglobose, maculate-punctate, prolonged into style $3–4^{mm}$ long, pluriovulate. Berry oval-globose, 5^{mm} long.

Potrero del Alto, Volcán Poas, C. R. alt. 2450^{m}, July 1888, *Pittier*, nos. 389 & 759 herb. nat. C. R.—Laguna del Volcán Barba, C. R., alt. 2755^{m}

Feb. 1890, *Tonduz*, no. 1949 herb. nat. C. R.—Forests of Achiote, Volcán Poas, C. R., alt. 2200^{m}, Nov. 1896, *Tonduz*, no. 10778.

Macroscepis congestiflora Donn. Sm.—Rami sicut petioli costae inflorescentia pilis longis patentibus fusci. Folia longiuscule petiolata obovata cuspidato-acuminata basi bilobata, nascentia villosa, adulta pilis brevibus appressis utrinque aspersa subtus pallida. Flores ebracteolati numerosissimi in umbellam globosam petiolum aequantem conferti, pedicellis pedunculum subaequantibus. Corollae calyce triente longioris tubus globosus glaber pallidus, limbus nigrescens intus papillosus tubo vix longior ultra medium suborbiculari-lobatus. Coronae squamae inclusae apice inflexo truncatae. Gynostegium brevissimum, caudiculis subnullis, disco stylino concavo.

Leaves $12–21 \times 8–12^{cm}$, margin pilose, basal lobes chiefly incumbent, nerves 7–9 to the side, petioles $3–4^{cm}$ long. Pedicels 25–40, $8–15^{mm}$ long; bracteoles linear-lanceolate, subequaling pedicels. Segments of calyx pilose, oblong-ovate, 10×5^{mm}. Tube of corolla 6^{mm} long; spreading limb pubescent beneath, nearly 2^{cm} in diam. Coronal scales subquadrate. Anthers tipped with an oval membrane 1^{mm} long. Gynostegium 2^{mm} high. Disk of style 2^{mm} in diam. Follicles not present.—A species with the foliage of *M. obovata* HBK. and the dense umbels of *M. Trianæ* Decne., but differing from both by the structure of the bractless flowers.

River-banks, La Sierra near Mataguescuintla, Depart. Santa Rosa, Guatemala, alt. 1500^{m}, *Heyde & Lux*, no. 6350 Pl. Guat. etc., qu. ed. Donn. Sm.

PROSTHECIDISCUS Donn. Sm., nov. gen. *Asclepiadearum*.—Sepala basi intus pauciglandulosa. Corolla alte partita reflexa, segmentis linearibus in praefloratione rectis et dextrorsum obtegentibus. Corona exterior infra apicem antheriferum columnae stamineae elongatae annularis 5-crenata, interior ad carinas 5 dorso filamentorum adnatas reducta. Antherae membrana inflexa terminatae, polliniis in quoque loculo solitariis compressis pendulis, caudiculis hyalinis brevibus. Discus stylinus in rostrum parum angustius cylindraceum superne complanatum productus. Folliculi lanceolato-ovoidei tuberculato-echinati.—Suffrutex volubilis. Folia opposita cordiformia. Racemi ex una axilla pedunculati.

Genus inter Cynancheas locandum ad Oxypetalum quodammodo accedit.

Prosthecidiscus Guatemalensis Donn. Sm.—Simul setulosus et glanduloso-pubescens. Folia longipetiolata suborbicularia cuspidato-acuminata lobis rotundatis et imbricatis cordata supra pilis brevibus parce onusta subtus praeter nervationem fuscam glandulosam et setulosam glabra et pallida, margine repando. Pedunculi petiolis sublongiores racemum superantes, pedicellis bibracteolatis flores aequantibus. Sepala lanceolata intus 3-5 glandulosa. Corolla extus pilis brevibus sparsissime obtecta intus glabra in praefloratione basi intrusa sepalis 4-plo tubo decies longior. Corona minuta, crenis tumidis. Ovaria stylos aequantia. Disci appendicium gynostegio 3-plo breviore adjecto corollam aequans.

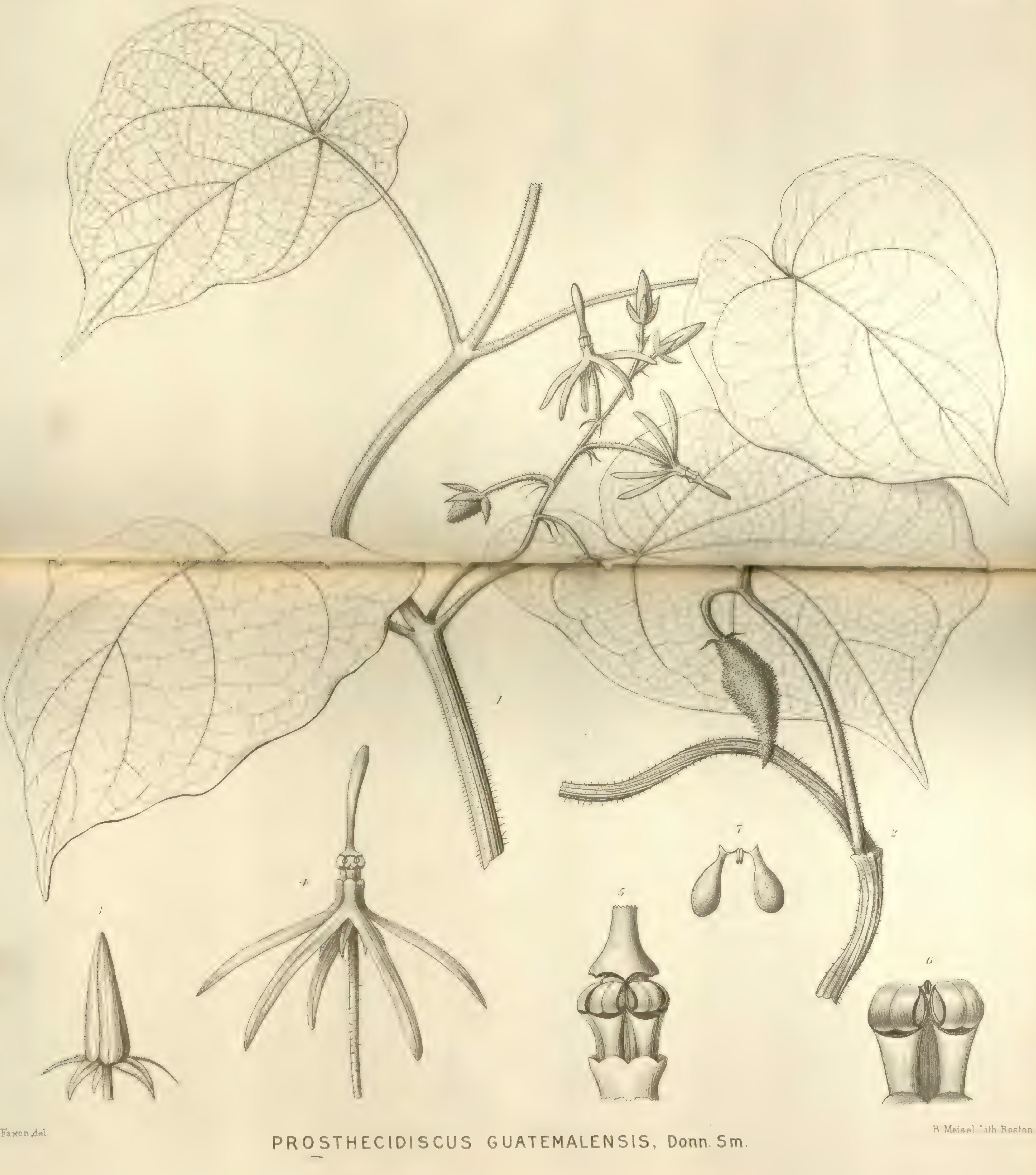
Leaves $9-13\times8-12^{cm}$, petioles $4-6^{cm}$ long. Racemes 6-12-flowered; bractlets filiform, $3-4^{mm}$ long. Flowers turning black in drying, 2^{cm} long. Anthers 1^{mm} long. Pistils 4^{mm} long. Matured follicles not present.

Cerro Gordo, 2½ leagues N. W. from Cenaguilla, Depart. Santa Rosa. Guatemala, alt. 1100^{m}, Sept. 1892, *Heyde & Lux*, no. 3845 Pl. Guat. etc., qu. ed. Donn. Sm.

Explanation of Plate XII.—Fig. 1, stem with leaves and flowers. Fig. 2, same with young follicle. Fig. 3, bud. Fig. 4, flower. Fig. 5, gynostegium with corona and base of stylar disk. Fig. 6, stamens. Fig. 7, pollinia.

Bourreria litoralis Donn. Sm.—Folia longe petiolata ex oblongo-ovato elliptica et utrinque acuta aut obtusa supra pilis e tuberculo ortis plus minus scabriuscula subtus pubescentia. Cyma laxiramosa, axibus filiformibus patulis. Calyx parvus dentibus acute triangularibus usque ad medium fere partitus corollae tubum aequans lobis dimidio brevior. Filamenta ad basin dilatatam villosa duabus partibus exserta.

A small tree. Branchlets and inflorescence glabrescent. Leaves variable in outline, sometimes oval and 7.5×5^{cm}, sometimes ovate- or obovate-elliptical and 12×6^{cm}, petioles $1.5-3.5^{cm}$ long. Cyme corymbose, chiefly exceeding leaves; bracteoles lanceolate, minute, caducous. Calyx 4^{mm} high, externally pilose, internally except canescent teeth glabrous. Lobes of corolla suborbicular, $8-9^{mm}$ long. Filaments inserted at apex of tube, 4^{mm} long, twice exceeding oblong anthers. Ovary, with style at apex bifid added, twice longer than calyx, stigmas capitate. Drupe not present.—By structure of flowers nearest to *B. formosa* Hemsl.



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PROSTHECIDISCUS GUATEMALENSIS, Donn. Sm.

Forests on the plain of Salinas, Golfo Dulce, Costa Rica, July 1890, *Pittier*, nos. 2787 and 2814 herb. nat. C. R.

TOURNEFORTIA NELSONI, proposed as a new species in BOT. GAZ. 23: 10. 1897, and founded upon no. 3615 of Nelson's collections in Guatemala, does not appear to differ from *T. petiolaris* DC.

Tournefortia subspicata Donn. Sm.—Praeter inflorescentiam corollamque subglabra. Folia longe petiolata obovato-elliptica utrinque acuminata discoloria supra minutissime lepidota, nervi laterales crebri cum venis subparallele transversis subtus conspicui. Cyma pluries dichotoma, floribus dissitis subsessilibus. Corollae tubus calyce vix bis longior, lobi ovato-lanceolati tubi dimidium fere aequantes. Pistillum calycem vix aequans.

Fruticose. Branchlets sulcate. Leaves $10–12\times4–6^{\mathrm{cm}}$, the upper often opposite or ternate, in drying rugose above and flavescent beneath; lateral nerves 8–10 to the side, like the veins nigrescent beneath and sparsely pubescent; petioles $2–3.5^{\mathrm{cm}}$ long. Peduncles terminal, erect, dichotomous, spikes recurved and like the corolla flavescent with a strigillose pubescence, pedicels chiefly $1–2^{\mathrm{mm}}$ long. Segments of calyx glabrous, becoming black in drying, ovate-lanceolate, 4^{mm} long. Tube of corolla 7^{mm} long, ampliate at throat, lobes 3^{mm} long and acute. Stamens subsessile at middle of tube; anthers linear, 2.5^{mm} long, muticous. Ovary glabrous, conic–ovoid, short style stigmatose below the conic apex. Drupes not seen.

Plateau of Volcán Turrialba, Costa Rica, alt. 2700^{m}, Jan. 1891, *Pittier*, no. 877 herb. nat. C. R.

Calceolaria sciadephora Donn. Sm. (§ CHEILONCOS Wettst. in Engl. et Prantl. Natuerl. Pflanzenfam. 4^{3b}: 55. § *Perfoliatae* Benth.)—Viscoso-pubescens. Folia subtus incano-tomentulosa grosse duplicato-dentata elongato-deltoidea in petiolos dimidio breviores late alatos basi dilatata dentata connatos abrupte contracta. Pedunculi elongati apice bracteato subumbellatim multiflori, pedicellis filiformibus. Calyx luteus corolla triente brevior labio postico bis longior. Antherae reniformes, loculis confluentibus proclinatis.

Suffruticose, erect, tall. Leaves discolorate, with petiole $5–7^{\mathrm{mm}}$ broad added 8^{cm} long, 3.5^{cm} broad, acute, base truncate, interpetiolar wing $9–12^{\mathrm{mm}}$ broad. Peduncles from upper axils, $4.5–7^{\mathrm{cm}}$ long; pedicels $2–3^{\mathrm{cm}}$ long,

chiefly umbellately, occasionally corymbosely, 9–14-fasciculate; bracts foliaceous, sessile, ovate-lanceolate, 2.5–3^{cm} long. Calyx colored like corolla, pubescent on both sides, segments ovate, 8–9^{mm} long. Corolla glabrous, 12–14^{mm} long; posterior lip truncate; 4–5^{mm} long; anterior lip oblong-obovate; aperture 7×4^{mm}. Cells of anthers oval, 2^{mm} long, continuing pendulous after anthesis. Ovary pubescent, with glabrous style added 8^{mm} long. Capsules not present in the specimens.—This alpine species is to be located between *C. tomentosa* Ruiz et Pav. and *C. calycina* Benth., resembling the former by leaves and flowers, and the latter by inflorescence, but differing from both by anthers.

Páramos de La Muerte at the limits of the forest growth, Costa Rica, alt. 3100^{m}, Jan. 1891 and 1897, *Pittier*, nos. 3486 and 10542 herb. nat. C. R.

Solenophora calycosa Donn. Sm.—Fusco-pubescens, nodis glabris. Folia ovata aut ovato-elliptica acuta basi inaequalia et obtusa punctata supra pubescentia subtus praeter nervos glabra duplicatim denticulata. Pedunculi petiolos subaequantes quam flos dimidio breviores medio bibracteolati uniflori. Calyx e basi turbinata tubuloso-campanulatus, lobis brevibus rotundis denticulatis. Corolla coccinea calycem 3-plo paene superans, lobis integris intus flavis et immaculatis.

Leaves unequal in the pairs, the greater 13–22×8–12^{cm}, the other a third smaller, lateral nerves 7–9 to the side, petioles 4–7^{cm} long. Peduncles about 5^{cm} long, bracteoles minute. Calyx reticulately veined, at base and within more densely pubescent, 3.3^{cm} long, adnate part 7^{mm} long, lobes 5^{mm} long and broad, teeth apiculated with a red gland. Corolla pubescent without, glabrous within, 8.5^{cm} long, limb oblique, lobes 1^{cm} long and 1.5^{cm} broad. Stamens included; filaments free, inserted at very base of tube; anthers 3^{mm} long, cohering quadrately, cells diverging at base. Gland of disk broad, bilobed, pubescent. Style pubescent, 5.5^{cm} long; stigma entire, stomatomorphous. Fruit unknown.

Slopes of Volcán Barba, Costa Rica, alt. 2300^{m}, July 1888, *Pittier*, no. 283 herb. nat. C. R.—Borders of Río Mancaron, Volcán Barba, Atlantic side, alt. 2100^{m}, Feb. 1890, *Tonduz*, no. 2022 herb. nat. C. R.

Episcia longipetiolata Donn. Sm. (§ CENTROSELENIA Benth. in Hook. Lond. Journ. Bot. **5**: 362.)—Praeter inflorescentiam puberulam glabra. Folia magna petiolis tenuibus vix ac ne vix longiora ovata obtusa denticulata membranacea nitida. Flores umbellatim congesti, pedunculis bracteosis et pedicellis brevibus. Segmenta calycina sicut bracteae linearia filiformi-attenuata, postico sejuncto paulum breviore. Corolla calyce bis longior saccata anguste tubulosa, lobis maculatis fimbriatis. Glandula sola integra.

Leaves 22–25 × 12–16$^{\mathrm{cm}}$, shortly cuspidate, slightly cuneate at base; nerves 14–15 to the side, like midrib fuscous beneath. Peduncles aggregated in the axils, 2–3$^{\mathrm{mm}}$ long; bracts several, 18–25$^{\mathrm{mm}}$ long, the exterior ones broader and shorter; pedicels 4–6, about 6$^{\mathrm{mm}}$ long. Segments of calyx 1.5$^{\mathrm{mm}}$ long, like bracts puberulous and entire. Corolla glabrous, straight, cylindrical, 3$^{\mathrm{mm}}$ broad, abruptly ampliate into limb, lobes equaling width of tube. Anthers ovate, 1$^{\mathrm{mm}}$ long, naked. Gland 1$^{\mathrm{mm}}$ high, black. Ovary globose, style a little shorter than corolla. Fruit not present.— To be located with *E. congesta* Hanst. and *E. glabra* Hanst., but differing remarkably from both by the petioles.

Borders of the road to Carrillo, Costa Rica, alt. 300$^{\mathrm{m}}$, June 1890, *Tonduz*, no. 2493 herb. nat. C. R.

Alloplectus stenophyllus Donn. Sm.—Omnibus in partibus glaberrimus. Folia uniuscujusque paris dimorpha, alterum petiolatum oblongo-aut lineari-lanceolatum, alterum subsessile acuminato-ovatum 3–4-ies minus. Pedunculi ex axillis foliorum majorum orti bini calyce breviores basi minute bracteolati. Calyx herbaceus, segmentis oblongo-lanceolatis, postico paene sejuncto, ceteris bis majoribus altius connatis corollae basi saccatae dimidium aequantibus. Antherae oblongae, loculis linearibus infra medium divergentibus.

Epiphytal. Larger leaf in the pairs 11–26 × 3–4$^{\mathrm{cm}}$, very acute, petiole 1.5–2.5$^{\mathrm{cm}}$ long; the smaller leaf 4–6 × 2–2.5$^{\mathrm{cm}}$. Peduncles 5–8$^{\mathrm{mm}}$ long, 1-flowered; bracteoles linear-lanceolate, 3–4$^{\mathrm{mm}}$ long. Calyx oblique; segments subentire, nerved, 13–17$^{\mathrm{mm}}$ long. Corolla pale-roseate; tube straight, 3$^{\mathrm{cm}}$ long, 1$^{\mathrm{cm}}$ broad at top; lobes rotund, subequal, 5$^{\mathrm{mm}}$ long. Stamens inserted a little above base of tube; filaments twisted after anthesis; anthers cohering, 5$^{\mathrm{mm}}$ long, affixed at middle, tumid at apex, sagittate below insertion. Gland posterior, single. Ovary 4$^{\mathrm{mm}}$ long, style 1.5$^{\mathrm{cm}}$ long, stigma stomatomorpho-bilobate. Fruit enclosed in the scarcely accrescent calyx oblong-ovoid, 1.5$^{\mathrm{cm}}$ long.

Forests of Suerre, Llanuras de Santa Clara, C. R., alt. 300$^{\mathrm{m}}$, Apr. 1896, *Donn. Sm.*, no. 6724 Pl. Guat., etc., qu. ed. Donn. Sm.— Rio Verde, Llanuras de S. Clara, C. R., alt. 200$^{\mathrm{m}}$, May 1896, *Donn. Sm.*, no. 6726 Pl. Guat. etc., qu. ed. Donn. Sm.— Forests of Tuis, C. R., alt. 650$^{\mathrm{m}}$, Nov. 1897, *Tonduz*, no 11512 herb. nat. C. R.

Alloplectus ventricosus Donn. Sm. (§ Hypocyrtoidei Hanst. in Linnaea 34 : 377.)—Folia cum caule glabra ampla oblongo-lanceolata utrinque acuminata integra subtus rubescentia dispari, cujusque paris majus rarius utrumque longe petiolatum. Pedunculi toti bracteosi apice congestiflori. Calycis segmenta sicut bracteae paulo majores pubescentia sanguinea ovalia. Corolla tomentosa calyce pallidior et bis fere longior superne inflato-ventricosa et ore bis amplior, lobis minutis erectis. Antherae oblongae bilobae.

Epiphytal; stem stout. Leaves shining, the larger in the pairs 28 x [illegible] and attenuated into a petiole 5^{cm} long, a third or a half longer than the other one; nerves 6–7 to the side, arcuately ascending to the margin, like midrib stout beneath. Peduncles stout, $1.5–2^{cm}$ long; bracts imbricating, not involucrate, orbicular-oval, 1.5^{cm} long, contracted into a short stipe; pedicels short recurved. Calyx oblique; segments obovate-oval, 12^{mm} long, apex denticulate, the posterior one a half smaller. Corolla declinate at base, above the middle obovate-ventricose, 2^{cm} long, 1^{cm} broad at top, lobes 2^{mm} long. Anthers 3^{mm} long. Gland posterior, solitary. Fruit puberulous, spherical, 12^{mm} in diam., exceeded by the accrescent calyx, dehiscing in 2 valves.—Related to *A. sparsiflorus* Mart.

Atirro, Prov. Cartago, C. R., alt. 600^m., April 1896, *Donn. Sm.* no. 6[illegible] Pl. Guat., etc., qu. ed. Donn. Sm.

Codonanthe macradenia Donn. Sm.—Praeter petiolos pedunculos flores puberulos glabra. Folia carnosa opaca elliptica utrinque acuta, costa in utraque facie immersa, nervis obsoletis. Pedunculi solitarii aut gemini petiolo bis longiores. Calyx pedunculum subaequans, segmentis filiformi-linearibus corolla recta leviter ventricosa dimidio brevioribus. Stamina inclusa. Disci glandula majuscula.

Epiphytal; stems sparingly branched, rooting at nodes, the younger rubro-maculate and puberulous. Leaves becoming pallid in drying, 3–[illegible] $1.5–2.5^{cm}$. Calyx oblique; segments fusco-puberulous on both sides, equal, 9^{mm} long. Corolla yellow, tube above gibbous base ampliate, cylindrical, 2^{cm} long, at throat 6^{mm} broad; lobes veiny, orbicular, 2^{mm} in diameter. Filaments free, inserted at base of tube; anthers connivent by pairs; cells gibbose, separated. Gland of disk stout, 2^{mm} high, apex retuse. Ovary puberulous, conic-ovoid, hardly 3^{mm} high; style villose, a half shorter than corolla. Berry oval-spherical, apiculate, 1^{cm} long, a little exceeding the augmented calyx, indehiscent.—Nearest to *C. gracilis* Hanst.

Borders of the river at Boruca, Costa Rica, alt. 460^{m}, Mch. 1892, *Tonduz*, no. 6769 herb. nat. C. R.— Forests of Santo Domingo de Golfo Dulce, C. R. Mch. 1896, *Tonduz*, no. 10051 herb. nat. C. R.— Hacienda de La Concepcion, Llanuras de Santa Clara, C. R. alt. 250^{m}, Apr. 1896, *Donn. Sm.*, no. 6719 Pl. Guat. etc., qu. ed. Donn. Sm.

Besleria imbricans Donn. Sm. (§ PODOBESLERIA Benth. et Hook.)— Folia longipetiolata magna oblongo-elliptica utrinque deorsum longius acuminata discoloria supra vix puberula subtus minute canescentia integra, nervis lateralibus utrinsecus circiter 16. Pedunculi elongati ad apicem racemuloso-pauciflori, floribus glabris. Calyx amplus glandulis rubris minute punctatus usque ad basin fere partitus in praefloratione clausus, segmentis orbiculari-ovalibus concavis valde imbricatis, postico minore et magis orbiculari, ceteris basi obliquis. Corolla coccinea quam calyx dimidio longior obovoidea breviter calcarata. Antherae globosae. Annulus inaequalis.

Herbaceous. Leaves $20–29 \times 9–11^{cm}$, pale beneath; nerves spreading, reaching nearly to margin; petioles $3–5^{cm}$ long. Peduncles 1^{dm} long; pedicels about 4, subequaling calyx. Segments of calyx $9–12^{mm}$ long. Corolla 2^{cm} long, mouth contracted; lobes rounded, 2^{mm} long. Stamens inserted near base of tube; filaments flat, $7–8^{mm}$ long; anthers 2.5^{mm} in diam., conniving by their apexes in a square; cells arcuate, confluent. Posterior half of annulus stout, oblique; the anterior half rudimentary. Ovary obovoid-globose, 3.5^{mm} long, glabrous; style stout, 8^{mm} long, glabrous, stigma conspicuously bilobed. Drupe not present.

Forests of Shirores, Talamanca, Costa Rica, alt. 100^{m}, Feb. 1895, *Tonduz*, no. 9192 herb. nat. C. R.

Besleria macropoda Donn. Sm. (§ PSEUDOBESLERIA Oerst.)— Tota praeter apicem ramulorum cum foliis nascentibus pubescentem glabra. Folia breviter petiolata oblongo-lanceolata aut -elliptica tenuiter acuminata basi angustata aut obtusiuscula calloso-denticulata crebre penninervia. Pedunculi longissimi, pedicellis gracilibus umbellatis pluribus. Segmenta calycina sejuncta aequalia lineari-lanceolata subulato-acuminata 3-nervia. Corolla aurantiacea e basi aequali urceolata calycem vix superans. Antherae reniformes. Annulus integer.

Apparently a tall herb. Leaves $10–14 \times 3–5^{cm}$, paler beneath; lateral nerves approximate, about 11 to the side, ascending nearly to margin, fus-

cous beneath; petioles canaliculate, 5–7^{mm} long. Peduncles 6–13^{cm} lo pedicels about 5–9, chiefly 2^{cm} long. Segments of calyx, with the 3^{mm} mucro added, 10–12^{mm} long. Corolla 12–13^{mm} long; lobes 2^{mm} long, superior two broader and connate. Stamens inserted below middle of tu anthers conniving by their apexes in a square. Ovary conic-ovoid, equa style. Fruit globose, 6^{mm} in diam., included in the not augmented ca apiculated by the remains of style, pericarp granulated.—Related to *B. la flora* Benth.

Damp woods at El Recreo, Costa Rica, July 1888, *Pittier*, no. 572 her nat. C. R.—Borders of road to Carrillo, C. R., alt. 300^{m}, May 1890, *Pittie* no. 2495 herb. nat. C. R.—Forests of Tuis, Prov. Cartago, C. R., alt. 65 Oct. 1897, *Tonduz*, no. 11358 herb. nat. C. R.

Besleria robusta Donn. Sm. (§ PSEUDOBESLERIA Fritsch in Eng. et Prantl. Natuerl. Pflanzenfam. 4^{3b}: 158; non Oerst.)—Cau petiolique crassi tomentosi. Folia coriacea integra maxima obovata acuta deorsum attenuata penninervia evenia supra glabra Flores paucifasciculati breviter pedunculati. Calyx alte partit extus sericeus intus glaber et rubescens, segmentis aequalibu oblongo-ovatis. Corolla glabra e basi vix gibbosa tubulosa calycem paulo superans, limbo aequali patulo.

Stem terete, near apex 1^{cm} in diam., internodes 1^{dm} long. Leaves 30 14^{cm}, becoming pale in drying, with scattered hairs beneath; nerves 12 the side, extending to margin, like midrib tomentose beneath; petioles 5 long, 5–6^{mm} thick, canaliculate. Peduncles sericeous, 6–8^{mm} long. Seg ments of calyx 12^{mm} long. Corolla apparently yellow, succulent, puberul within, 14^{mm} long, 3^{mm} wide, suberect; lobes round, 3^{mm} long. Stamen inserted below middle of tube, the rudimentary one 4^{mm} long; anthers re form, cohering; cells oblong, 2^{mm} long, connective triangular. Annul equal. Ovary glabrous, oblong-conical, with equal style added as long as calyx, stigma distinctly bilobed. Fruit not seen.—Nearest to *B. Riedeliana* Hanst.

Forests of Tsâki, Talamanca, Costa Rica, alt. 200^{m}, Apr. 1895, *Tonduz*, no. 9556 herb. nat. C. R.

Tabebuia sessilifolia Donn. Sm.—Glabra. Folia oblanceolata cuspidato-acuminata in basin sessilem sensim attenuata. Pedun culi ad apicem bracteosum ramulorum pauci-aggregati. Calyx coriaceus amplus pedunculum aequans spathaceo-fissus demum bilobus, tubo campanulato, lobis oblongo-ovatis integris enervi Corolla infundibuliformis intus praesertim ad lobos tuberculose-

puberula. Discus pulvinatus. Ovarium conicum lepidotum, ovulis in utroque loculo 4-serialibus.

Leaves simple, crowded toward the end of branchlets, membranaceous, minutely lepidote, 13-17 × $4.5–5^{cm}$, midrib stout beneath; lateral nerves spreading at nearly a right angle, 14–18 to the side, conspicuous beneath. Peduncles stout; bracts linear, 1.5^{cm} long. Calyx smooth and shining, becoming black in drying, 3.2^{cm} long. Corolla (imperfectly developed in the specimens) scarcely twice longer than calyx, eternally glabrescent, tube at base 5^{mm} broad. Stamens inserted a little below middle of tube, subexsert; cells of anthers elliptical, 4^{mm} long, divaricate. Disk 3^{mm} high, 5^{mm} broad. Ovary 5^{mm} long, lips of stigma obtuse. Capsule not present.—Approaching *T. obtusifolia* Bur. by its equally large calyx, but differing by sessile and acuminate leaves and by inflorescence.

Forests of Tablazo, Costa Rica, alt. 1800^{m}, Apr. 1893, *Tonduz*, no. 7937 herb. nat. C. R.

Aegiphila odontophylla Donn. Sm. (§ CYMOSAE Schau.)—Pubes pallide ochracea, in ramulis inflorescentiaque tomentulosa, in calyce foliorumque nervis subfurfuracea. Ramuli obtuse quadrangulati verrucosi. Folia praeter nervos glabrescentia oblongo-obovata acute acuminata in petiolum attenuata, ambitu toto fere serrato. Pedunculi petiolos subaequantes cymis pluries dichotomis laxifloris paulo breviores. Calyx obconicus venosus, lobis semiorbicularibus nervo excurrente apiculatis. Corolla glabra, lobis ovalibus.

Leaves opposite, $1–1.4^{dm}$ × $3.5–5.5^{cm}$; lateral nerves 8–10 to the side, like veins pubescent and conspicuous beneath; margin, except at base, conspicuously serrate, teeth antrorse and mucronate-apiculate; petioles $1–1.5^{cm}$ long. Cymes axillary, bracteoles subulate, flowers 4-merous. Calyx $5–6^{mm}$ high, externally furnished with a few large glands, lobes 1.5^{mm} long. Corolla hypocraterimorphous, 1.2^{cm} long; lobes obtuse, 5^{mm} long. Drupes not present.

Forests on southern slope of Vulcán Barba, Costa Rica, alt. 2100^{m}, July 1888, *Pittier*, no. 288 herb. nat. C. R.

BALTIMORE.

CENTROSOMES IN PLANTS.

L. GUIGNARD.

THERE are few questions in cytology to which so much attention has been paid in recent years, especially by zoologists as that of centrosomes and directive spheres. First observed as is known, in animal cells undergoing division, they were later also found in the same cells in a resting stage. The presence of centrosomes in plants had not been demonstrated before my investigation of the subject. But, according to recent work, instead of being of general occurrence in plants, as was believed, they may be limited to the lower groups of the plant kingdom. However, in a subject so difficult, in which the record of new observations may be expected daily in consequence of the incessant progress of investigation, I do not believe absolute assertion of such an opinion is prudent.

Without entering into details, it will suffice to recall first that in animal cells the morphological and microchemical characteristics of the attractive spheres and centrosomes may be far from uniform. It is at least agreed that the centrosome is to be considered the important part of the sphere. Usually it is a refractive corpuscle, sometimes of extreme smallness. The sphere itself is formed of a substance which can be differentiated into two zones; one clear toward the center, the other granular toward the periphery. Also, it is often poorly defined, and of a refrangibility different from that of the surrounding protoplasm. The radial striation which usually surrounds it has its origin partly in the centrosomes, partly in the central region of the sphere.

In animal cells in the resting stage the sphere is often lacking, or is indicated only by a slight protoplasmic condensation around the centrosome. Sometimes it is even disorganized and

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then reorganized before the division of the nucleus. It is formed of that substance which certain authors have called archoplasm, or kinoplasm, in order to distinguish it from the nutritive protoplasm or trophoplasm. It can be said in a general way, therefore, that the centrosome is the fundamental element of the sphere, since often it alone persists, and it is the centrosome which has the greatest affinity for staining fluids. However, it is known that in certain cases, observed especially by Van der Stricht and von Rath, the attractive sphere conceals the centrosome, but one is not justified perhaps in concluding that the latter element is in such a case completely absent.

Some observers have asserted, also, that the centrosomes and the spheres have no distinct existence, but are appearances resulting from certain activities of the protoplasm.

It does not seem possible at present to characterize the centrosomes by their composition, or by the manner in which they behave in respect to stains. Yet Heidenhain, and other authors claim that the centrosomes are composed of a particular chemical substance; while Viessing thinks that to find the specific character of these bodies it is necessary to study, not their chemical composition, but their position in the center of a protoplasmic radiation which they serve as a point of attachment. In the resting animal cell there has been observed a single centrosome, sometimes two neighboring centrosomes, sometimes even numerous centrosomes lying side by side and forming the "microcentre" of Heidenhain, or the "centriole" of Boveri. In this last case the typical centrosome is replaced by a group of granules, which divides, like a typical centrosome, into two at the beginning of nuclear division.

Often the centrosomes, very small and scarcely visible at the moment of nuclear division, increase in size during that process, divide at the same time as the nucleus, and then return to their former condition and cease to be recognizable. There are several authors, however, who do not consider the centrosomes permanent organs of the cell, but such is not the opinion of the majority of zoologists, who have observed centrosomes in cells of very diverse nature and in the period of complete rest. Their appearance in animals seems general and in all phases of the life of the cell.

It may prove, however, not to be the same with plants. The observations of Farmer, of Strasburger and his pupils, tend to show that among plants these elements occur only in the thallophytes and lower bryophytes; and that they may not exist at all in vascular cryptogams and phanerogams. Such a difference between thallophytes and cormophytes on the one hand, and between the latter and animals on the other, is somewhat surprising when one considers the analogies presented in the fundamental structure of the cell, especially in the phenomena of nuclear division, in the great majority of plants and animals. However, the question may depend wholly upon the difference between purely theoretical views.

Among lower plants in which centrosomes have been described by the preceding observers, they present morphological variations analogous to those with which we are familiar in animals. For example, in Fucus, in the developing oogonia and the segmenting eggs, Strasburger has observed centrosomes surrounded by well differentiated radial striations. Swingle has made similar observations in the vegetative cells of Sphacelaria with this difference, that instead of having the form of a rounded granule, the centrosome resembles a little box (boitonnet), a dumb-bell, or is club-shaped. This centrosome divides, persists during the resting period, and varies but slightly in size. Among these plants the centrosome seems to be without any clearly differentiated surrounding sphere, but the sphere has been observed by Farmer and Strasburger in some of the Musci.

Among fungi (Peziza, Ascobolus, Erysiphe) Harper has found, instead of an ordinary centrosome, a granular body of discoid form from which extend radial striations. According to Fairchild Basidiobolus has barrel-shaped spindles; that is, truncated at their polar extremities, and composed of several strands of threads, each strand being terminated by a distinct granule which stains readily. Similar strands have been observed in animals (Ascaris, Cyclops, etc.), but here it was a form merely transitory which precedes the normal bipolar stage which, when attained, shows centrosomes of the usual type.

These observations all go to prove that our conception of centrosomes should be much broader and more general than at the beginning of our acquaintance with them.

One of the principal arguments against the existence of centrosomes among the cormophytes is drawn from the method of formation of the nuclear spindle. Many observers have stated that the spindle, instead of being bipolar from the first, begins with a variable number of poles; often more than a dozen, according to Osterhout, in the spore-mother cells of Equisetum; a half dozen or less, according to Mottier, in the pollen mother cells of Lilium, Podophyllum, etc. But at a fixed time these multipolar spindles always become bipolar, either by fusion, or by the drawing in of the filaments which form the multiple cones of the primitive figure. Neither at the summit of these multiple cones, nor at the extremities of the bipolar spindle derived from them, have these authors seen anything showing the character of a centrosome. It may be asked, then, what are the forces which thus change the multipolar to the bipolar spindles. If, according to the preceding observers, neither centrosomes nor anything capable of their function is present, one must invoke a mechanical explanation for these changes. Can it be the chromosomes which orient the achromatic threads of the spindle? Well-known facts tend to show precisely the contrary. If one believes in the absence of any kinetic center, it only remains to admit with Strasburger that the forces in play reside in the kinoplasm, independent of any special morphological differentiation. The opinion of a distinguished scientist may perhaps be given some weight.

Even though all earlier observations upon the presence of attractive spheres and centrosomes in different cormophytes may be regarded as inexact, one cannot doubt that the bodies recently described and figured by Webber in the pollen cells of Zamia, although they serve at a given moment in the formation of the cilia of the antherozoids of this cycad, are centrosomes, and the same thing appears likely to be the case in Gingko studied earlier by Hirase.

The following are the results of my recent investigations of the pollen mother cells of various phanerogams (*Nymphæa alba, Nuphar luteum, Limodorum abortivum*), examined after fixation in Flemming's fluid and other suitable reagents.

In Nymphæa, which is of particular interest, the adult mother cell contains an excentric nucleus, lying very near the wall, the rest of the cell being almost entirely filled with starch. At the commencement of the prophases of division the cytoplasm assumes a filamentous appearance around the nucleus, in which the chromosomes (apparently thirty-two in number) are peripherally placed in contact with the nuclear membrane, and in addition to the nucleolus a certain number of very fine achromatic threads can be distinguished.

In the neighborhood of the nucleus certain stains, such as a mixture of methyl-green, fuchsin, and orange G, bring out one or two small differentiated bodies, sometimes of homogeneous aspect, sometimes provided with a more deeply stained central granule and sometimes more numerous. At certain stages they act as points of attachment for cytoplasmic threads directed towards the nucleus, and form the first outline of the nuclear spindle. Sometimes tripolar or even quadripolar spindles are found, but the final figure never has more than two poles, occupied by a small sphere which has for its center either a single granule or several granules in a group, whose deep green color, brought out by the stain indicated, is like that of the chromosomes. These elements can also be stained by other methods. On account of the small number of multipolar spindles that I have observed, I am not able to suggest, at present, in what manner the multipolar spindles become bipolar.

The nuclear spindle forms on the side of the cell, becoming curved in accordance with its contour. The two cones which compose it, and whose bases correspond to the nuclear plate, elongate and incurve more and more, until the spindle becomes crescent-shaped, and sometimes twisted upon itself in the form of an S. The length of the crescent often equals half the circumference of the cell. This singular elongation appears to depend upon polar bodies which always occur at the points of the spindle. During the process sometimes these bodies are represented by a sphere with one or more granules, and sometimes the sphere does not appear stained as the rest, a difference which may be attributed, in part, to the variable action of the reagents. In every case these bodies certainly represent centrosomes. Striations are also often to be seen extending from them into the cytoplasm.

Often, also, the ends of the spindle are extended into a slender point, formed by several granules disposed in a line. One might think that in this case there is no centrosome at the pole, but, in my judgment, it is to be explained by the dissociation of the primitive centrosomes, whose numerous granules have disposed themselves in this way. The reaction of these elements to stain certainly suggests this view.

The centrosomes are found in all the phases of nuclear division. After the formation of the daughter nuclei they can still sometimes be seen, becoming indistinct but not actually disappearing. They are found during the second division of the mother cell.

In Nuphar the nucleus is not lateral, but occupies a central position in the cell, which is completely filled with starch grains. The cytoplasm presents an alveolar appearance. The character of the nuclear division differs from that in Nymphæa in being of the normal type. It is to be remarked that the chromosomes are twelve in number, their arrangement in the nuclear plate stage being in groups of four, observed by Calkins in the ferns, and by many zoologists in the copepods and other animals. At the beginning of the prophases multipolar spindles are also found, at whose extremities there is very often a granule or a more or less distinct sphere serving as the point of departure for achromatic threads. At later stages the polar bodies or centrosomes resemble those of Nymphæa, but the bipolar spindle, formed at the center of the cell, always lies as in ordinary cases.

It is exceedingly difficult to detect the bodies representing centrosomes in Limodorum. Multipolar spindles are very frequent, and in general their branches are very numerous and very variable in appearance. At the extremity of many of them, however, there is seen a granule, or a small mass of substance more stained than the rest of the cytoplasm. During the formation of the bipolar spindle, those granules nearest the points subsequently occupied by the two final poles, points determined by the form of the cell, seem to persist, the others disappearing. It can be supposed that several isolated bodies sometimes unite to form a single centrosome, for, after the formation of the bipolar spindle, bodies are often seen at each pole. A distinct sphere was not observed, but time after time very delicate radiations from each pole were seen.

To summarize, I may say that it does not appear permissible to advance the formation of multipolar spindles, which may be accidental or normal, as an argument against the existence of dynamic centers during nuclear division. It remains a fact that at a certain time there appear in the cytoplasm bodies distinct from the ordinary granules. It is possible that the construction of the multipolar figures may be independent of the elements which form centrosomes. It may also be true that centrosomes are not always definite morphological units. But it is none the less certain that the higher plants possess differentiated elements whose rôle is the same as that of those analogous bodies observed in the lower plants and in animals.

PARIS.

NEW SPECIES AND EXTENDED RANGES OF NORTH AMERICAN CARYOPHYLLACEÆ.

B. L. ROBINSON.

(WITH PLATE XIII)

SINCE the publication of the last fascicle of the *Synoptical Flora*, containing a revision of the North American Caryophyllaceæ, four additional species, belonging to this family and growing within the range of the work mentioned, have come to the notice of the writer. These plants have been recently discovered in widely separated parts of our continent, and, with the possible exception of the Drymaria mentioned below, are undoubtedly indigenous, so that together they form a noteworthy addition to our already rich representation of this attractive family.

Stellaria oxyphylla.—Decumbent and rooting from the lower nodes: stems striate, leafy, dichotomously branched above, 3^{dm} or more in length, glabrous except along a puberulent line upon the dorsal surface of each branch: leaves elongated, lanceolate, caudate-attenuate, becoming 1^{dm} or more in length, 8 to 13^{mm} in breadth, nearly concolorous, minutely warty upon both surfaces, sparingly or even obsoletely ciliolate upon the margin, gradually attenuate to sessile somewhat connate bases; midrib pale, prominent upon the lower surface; veins finely reticulated (an intramarginal one clearly visible by transmitted light): peduncles slender, spreading or at length deflexed, 25 to 35^{mm} long, often nodding or recurved at the summit, borne in the forks of the branches and in the axils of the highest leaves: calyx glabrous, subturbinate at the base; sepals lanceolate, attenuate, in fruit about 6^{mm} in length, scarcely striate, persistent, becoming dry and somewhat scarious: petals half to two-thirds as long, white, oblong, cleft only about a quarter of their length or even less, the teeth often unequal: stamens five: styles three: ovary globose: valves of young fruit three, bifid; seeds not seen.—*Alsine Jamesii* Holzinger, Contrib. U. S. Nat. Herb. **3**: 216, in part, *i. e.* as to no. 608.—Collected in flower July 8, 1892, on St. Joseph's river, Wiessner's Peak, Kootenai county, Idaho, at 1800^{m} altitude, by Messrs. Sandberg, MacDougal, and Heller, no. 608, and distributed as *Alsine Jamesii* from the Department of Agriculture.

This species has much the habit of the Japanese *S. Yezonesis* Maxim., which, however, is decandrous, has more deeply cleft petals and exhibits some other differences. *S. oxyphylla* is on the border line between Stellaria and Arenaria and indeed suggests at first sight *Arenaria macrophylla* Hook., although slight examination of the pubescence and calyx shows it to be quite distinct from that species, and, all points considered, there can be little doubt that its affinities are with Stellaria. It offers a drastic example of the deplorable haste with which the so-called reform of our nomenclature has at times proceeded; for the *Alsine Jamesii* of Holzinger, supposed to represent *Stellaria Jamesii* Torr., in reality rests upon a mixture of the very different *S. oxyphylla* (no. 608) and a luxuriant form of the cosmopolitan *S. media* Cyrill. (no. 78), species so widely diverse that it is truly difficult to see how the confusion could have occurred. It will be rather interesting to observe whether *Alsine Jamesii* Holzinger is to rest upon its synonym (which by the way is not wholly correct, the original name being *Jamesiana*) and stand for a species which Mr. Holzinger may never have seen, certainly never examined, or whether as in other cases the name is to be taken as referring to the plants for which its author was actually using it.

Stellaria Washingtoniana.—Delicate annual: stems decumbent, leafy, branching from the lower nodes or often quite simple, pubescent with fine white spreading or slightly felted hairs; branches simple or nearly so: leaves ovate, acute, subpetiolate, thin and of delicate texture, not lucid, about [illegible] long, 5 or 6^{mm} broad, puberulent or glabrous, finely ciliate near the contracted petiolar base, 1-nerved but showing in transmitted light pinnate veins as well as an intramarginal one: peduncles two to several, axillary, solitary, filiform, pubescent, about 1^{cm} in length, spreading, 1-flowered: calyx campanulate, externally pubescent; sepals four, ovate, 2 to 3^{mm} long, narrowed to an obtusish apex, delicate in texture, herbaceous except on the margins, obscurely 3-nerved: petals none: stamens eight: styles three, recurved: ovary and capsule ovoid; seeds dark reddish brown, minutely roughened.— Collected in flower and fruit in alder woods of the upper valley of the Nesqually upon slopes of Mt. Rainier, Washington, June 18, 1895, by Professor O. D. Allen and forming no. 157 of his valuable set of Cascade mountain plants; also collected but chiefly in a sterile state on clayey banks near Lake Cushman, August 1895, by Professor C. V. Piper.

The affinities of the species are obviously with *S. obtusa* Engelm., *S. crispa* Cham. & Schlecht., and *S. calycantha* Bong. *S. obtusa*, however, is essentially glaborus, and has thicker obtuser apparently glaucescent leaves and sepals, while *S. crispa* is wholly glabrous and has narrower attenuate sepals, which are more or less distinctly ribbed near the base. *S. calycantha*, on the other hand, bears at least its lower flowers in the forks of a distinctly cymose inflorescence.

ARENARIA ULIGINOSA Schleicher.— This species, long known, although somewhat local, in alpine and boreal regions of Europe, as well as in Siberia and Greenland, has been collected on slaty detritus near Rama, northern Labrador, at about 300^{m} altitude, by Mr. J. D. Sornborger, August 1897. While the species appears in Watson's Bibliographical Index, under the name *A. stricta*, it has not, to the knowledge of the writer, been hitherto observed upon continental America, its citation in the Index being due to the fact that Dr. Watson included Greenland in the territory covered, as well as to the circumstance that he included in his synonymy of the species in question the quite different *A. Rossii* R. Br. As will be seen from the accompanying *fig. 6* in *Plate XIII*, *A. uliginosa* can readily be distinguished from any of the related North American species by its foliage closely tufted at the base and by its very long and slender almost naked stems and peduncles. In these, as in all other observed characters, Mr. Sornborger's specimens correspond exactly with those from the Old World. The nature of the occurrence in Labrador, together with the presence of the species in Greenland, leaves little doubt as to the indigenous character of the Labrador specimens.

This species has a rather complicated synonymy which has led to so much confusion that it will be best to cite its bibliography here in some detail. Its names have been as follows:

Spergula stricta Swartz, Vet. Acad. Handl. Stockh., **20**:229. 1799; and in Schrad. Journ. 1800^2: 256.

Arenaria uliginosa Schleicher, "Cent. exs. 1. n. 47," acc. to Lam. & DC. Fl. Fr. **4**:786. 1805, where a good description is given; DC. Ic. Pl. Gal. Rar. 14 (excl. syn. in part), *pl. 46*; and Prodr. **1**:407; Hook. f. Arct. Pl. 287, 322; Gray, Proc. Acad. Philad. 1863:58; Hook. f. Stud. Fl. Brit. Is. ed 3. 63; Britton, Mem. Torr. Club. **2**: 37.

Alsine stricta Wahlenberg, Fl. Lapponica 127. 1812; Fl. Dan. *pl.* 29 Nyman Conspect. 118, and continental authors generally.

Arenaria Lapponica Spreng. Syst. **2**:402. 1825; Hook. f. & Jacks. Ind. Kew. **1**:179.

Sabulina stricta Reichenb. Fl. Germ. Excurs. 789. 1832.

Stellaria stricta Sw. ex Steudel, Nomencl. ed. 2, **2**:637. 1841.

Arenaria stricta Wats. Bibliog. Index 98. 1878, at least as to the first three synonyms.

From the above synonymy it is evident that there is a considerable choice of names and that the selection by different authors is likely to vary somewhat according to individual ideas of classification and nomenclature. It is clear, however, that those who unite Alsine and Arenaria and who also prefer the "first correct combination" must choose *Arenaria uliginosa*, the name current in England. It is to be regretted that the statements made in regard to this species in the *Index Kewensis* are most conflicting and inaccurate, being as follows:

Under Alsine

A. stricta, Mert. and Koch, in Roehl. Deutschl. Fl. iii. 278 = Ar. stricta.

A. stricta, Wahlenb. Fl. Lapp. 127 = Ar. lapponica.

Under Arenaria

A. lapponica, Spreng. Syst. ii. 402.—Lappon. [given as a valid species of restricted range].

A. uliginosa, Schleich. ex Schlecht. in Ges. Naturf. Fr. Berl. Mag. vii. (1813) 207 = Arenaria stricta.

Under Sabulina

S. stricta, Reichenb. Fl. Germ. Excurs. 789 = Arenaria stricta.

Under Spergula

S. stricta, Sw. in Vet. Acad. Handl. Stockh. xx. (1799) 229 = Arenaria stricta.

Now of these six clear references to this well-known European plant all are incorrect. Four refer it to *Arenaria stricta*, but the only plant of that name cited by the *Index Kewensis* is the common and wholly distinct American species of Michaux's *Fl. Bor. Am.* 1: 274, while the other two references to the plant under discussion maintain for it the name *Arenaria Lapponica* Spreng. (1825), which is much antedated both in Arenaria, Alsine, and Spergula, and is accordingly supported by no code or usage whatever. As further incidents in this confusion may be mentioned the neglect of Lamarck & De Candolle's early publication of *Arenaria uliginosa*, and the omission of Watson's *Arenaria stricta* which, as its synonymy clearly shows, was employed in a sense wholly different from *A. stricta* of Michaux.

In 1890 (Mem. Torr. Club **2**: 37) Dr. N. L. Britton exactly expresses the position of the present writer, by his footnote, which runs as follows:

> "*Arenaria stricta*, S. Wats., Bibliog. Index, Polypet. 98 (1878), is based on *Spergula stricta*, Sw. Act. Holm. xx. 229 (1799), which is *Alsine stricta*, Wahl. Fl. Lapp. 127 (1812), and the oldest name available for it appears to be *Arenaria uliginosa*, Schleich. Dr. Watson's binomial of 1878 can in no way displace Michaux' of 1803."

This position, stated so positively by Dr. Britton in 1890, is of course quite contrary to the unwise Madison rule of 1893, which asserts the immutability of an older specific name even when the species is transferred to a genus already containing an identical specific name of later date. As the writer has elsewhere shown, this provision, together with the dictum of "once a synonym always a synonym," would give a power to any thoughtless worker of displacing forever many valid specific names. Such a rule can certainly never attain general acceptance, and it is a pleasure to see from Dr. Britton's note of 1890, how clearly he sees its disadvantages. Nevertheless it is a matter of surprise to note that he did not feel impelled to follow the Madison rules in the *Illustrated Flora*, nor even in the *List of Pteridophyta*, etc., (which was expressly prepared to illustrate the nomenclatorial system of the American Association), for in both works *Arenaria stricta* Michx. is still kept up, although the Madison rule would clearly establish *Arenaria stricta* (Sw.) Wats. for the European plant and force the adoption of *A. Michauxii* Fenzl. for the American. Dr. Britton's usage can scarcely be due to oversight, for he had so recently shown a complete understanding of the existence and distinctness of the two species concerned. But if, on the other hand, it is to be taken as a very sensible exception to an undesirable rule, it may be asked: What is to become of a rigid system, if even very sensible exceptions are permitted?

Spergularia borealis Rob.—Until recently this species has not been known south of Wells, Maine, where collected by Mr. Walter Deane. However, President E. Brainerd has brought to the notice of the writer specimens collected at North Dennis on Cape Cod by the Rev. C. N. Brainerd, and still more recently specimens from the banks of Seekonk river near Providence, Rhode Island, have been sent to the herbarium of the New England Botanical Club by Mr. J. F. Collins. These more southern specimens agree in all observed points with the northern. The best distinctive features appear to be the short blunt sepals and large seeds. *Figs. 2* and *3* of *Plate XIII* will assist in distinguishing this species from *S. salina* Presl., the only member of the genus with which it is likely to be confused. An examination of the specimens of Spergularia in the herbarium of the Middlesex Institute, recently deposited in the herbarium of the New England Botanical Club, shows that *S. borealis* also grows on the salt marshes of the Mystic river, near Medford and Everett, Massachusetts, where discovered and distinguished from *S. salina* by Mr. F. S. Collins. Upon this material rests the *Lepigonum medium* of Dame & Collins, *Flora of Middlesex County*, p. 1 Now that the species is known within easy reach of many loca

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ROBINSON on CARYOPHYLLACEÆ.

botanists, it is to be hoped that it will receive further field study, which may lead to the discovery of additional distinctive features.

Drymaria cordata Willd.—This common and well known species, widely distributed in the tropics of both hemispheres, but not, to the knowledge of the writer, hitherto reported from any part of the United States, has recently been collected on the banks of the Withlacoochee river near Istachatta, Florida, by Mr. A. H. Curtiss. Whether the plant is indigenous in this locality has not been determined. The seeds, which are of small size, may well have been brought from the tropics in mud clinging to the feet of migratory birds or in some such way. It appears that in warm countries this species is apt to be rather common, where it occurs at all, and the fact that it has not been observed in Florida before would rather suggest a recent introduction. *Fig. 1* on *Plate XIII* is drawn from a Mexican specimen, not from Mr. Curtiss' plants which, although unmistakably of this species, are sterile.

Gray Herbarium.

EXPLANATION OF PLATE XIII.

The original drawings reduced one-half in the plate.

Fig. 1. *Drymaria cordata; a*, habital sketch; *b*, node showing cleft stipule *st*.

Fig. 2. *Spergularia salina; c*, old flower with mature capsule; *d*, seed.

Fig. 3. *Spergularia borealis; e*, seed, drawn to same scale as *d; f*, branchlet, showing at the left an old flower with blunt sepals and much exserted capsule.

Fig. 4. *Stellaria Washingtoniana; g*, fruiting plant; *h*, outside surface of sepal; *i*, inside surface of sepal; *j*, stamen; *k*, ovary.

Fig. 5. *Stellaria oxyphylla; l*, habital sketch; *m*, sepal; *n, o, p*, petals; *q*, stamen; *r*, ovary.

Fig. 6. *Arenaria uliginosa; s*, habital sketch; *t*, sepal; *u*, petal; *v*, stamen; *w*, ovary.

ON COLLECTING AND PREPARING FLESHY FUNGI FOR THE HERBARIUM.[1]

EDWARD A. BURT.

(WITH PLATE XIV)

OUR North American flora is so rich and its territory so large, in comparison with the number of botanists engaged in its study, that the knowledge of even the distribution of some large classes of its plants is very inadequate, being based chiefly on works covering comparatively limited regions. This is especially true for the fleshy fungi (Basidiomycetes and larger Ascomycetes), the larger number of which are rapidly putrescent and therefore not usually found in the collections of professional botanical collectors and explorers, to whom we owe so much in other classes. The larger herbaria and exsiccati are also, for the most part, comparatively poor in their representation of our fleshy fungi, exclusive of the more persistent Polyporeæ, Hydneæ, and Thelephoreæ. My personal observation leads me to believe, however, that there is no class of plants concerning which people who are not botanists would more gladly have a botanist's knowledge than of the class Basidiomycetes, and there is probably no class of plants whose collection and study in one's home locality can be carried on with greater interest for a series of years, provided one has sufficient freedom during the summer and autumn months to make collections when the weather conditions make these plants most abundant, to take full notes at the time of collecting and while the plants continue fresh, and, finally, to prepare and preserve his plants so that they may serve as a nucleus for comparison and study in following years. It is the aim of the present paper to point out practical methods of doing this work so that it may afford results and collections of permanent scientific value.[2]

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[1] Read before the Vermont Botanical Club February 5, 1898.

COLLECTING.— For collecting fleshy fungi, I have seen nothing better than a common splint basket with hinged cover (*fig.* 1); such a basket as is often used for a lunch basket at picnics or as a workman's dinner basket, and is to be obtained for twenty to thirty cents. My preference is for a size about 14in × 9in × 11in deep. Such a basket is much lighter than a tin box; it is provided with a pair of handles by which it may be carried suspended from the arm; the cover protects the contents from injury by direct sunlight and, in going through woods and thickets, from injury by branches. The convex cover is thrown back while one stops to make a collection and it forms a receptacle 3in deep, very convenient for the temporary arrangement of the material. Fleshy fungi find too close an atmosphere in a tin collecting box and rot down much sooner than in the basket.

It is well to carry in the basket a chisel for the removal of species growing on wood, and a trowel-like knife for those growing deep in the ground or for those which it is desirable to carry home in the original clusters. One or two small tin or pasteboard boxes should also be provided to hold the more delicate and fragile species. The basket should contain a package of thin, but strong and tough, uncolored paper—a heavy weight tissue paper which does not become too tender when moist is good. This paper should be cut into squares and rectangles varying in size from 6in square to 1ft × 2ft.

Whenever a species that is to be saved is found, it should be collected, if possible, in sufficient quantity for several ample specimens, pains being taken to obtain a full series of stages, both young and mature, and to take up each plant with as little injury as possible in order to show the base of the stem and any sclerotoid or radicated parts present. A sheet of paper large enough for the collection is then selected from the package and spread out in the open cover of the basket. The plants are arranged on the central portion of the paper so as to form a compact pile, and in this pile is placed a slip bearing the written field notes of this collection. The four corners of the sheet of tissue paper are raised and brought together above the pile and twisted together so as to draw the sheet closely about the pile of fungi and hold the plants firmly, forming a compact package in which the individual plants cannot be shaken about. These packets should be bedded closely together in the basket so that they may be carried without shaking. Very heavy specimens weighing several pounds each should be placed at the bottom of the basket preferably, or resting one on the other at one of its ends.

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[2] Cf. Humphrey: The preparation of agarics for the herbarium. BOT. GAZ. 12: 271. 1887.

The fleshy fungi are very fragile, yet I have made many collecting trips in the rugged Green mountains, collecting in rough wooded places through the greater part of the day, and driving towards its close from five to twelve miles with my basket of specimens, or oftener carrying the basket knapsack-fashion on my back while riding a bicycle, and yet have found the plants in perfect condition in the packages when home was reached. During the annual field-day of our Botanical Club last September, Professor Jones and I collected fleshy fungi on the ascent up the west side and on the summit of Mt. Mansfield during the first day, and on the second day down the steep eastern slope through the forest to Smugglers Notch and through the Notch. Then there was a rapid ride over a rough road to Jeffersonville and a further ride of several hours by rail home. Our collections came through in fine condition, however, and gave a large number of interesting species a place on the state list. The paper wrapper about each package gives rigidity and elasticity to the contents of the basket, retains the original moisture of the plants well, and does not wholly prevent the circulation of air through the basket. If decay begins in any package, it is confined there. In addition to this, the great advantage of having each species with its field notes kept by itself, will be appreciated by every one whose work has been with the lower cryptogams.

FIELD NOTES.—Field notes are of great importance[3]; they should always be made for each species which one does not already know well, and also for any collection which impresses one, although in a vague way, perhaps, as strange or unusual. Such notes afford in many cases decisive characters in the determination of the species. Some characters are so evanescent that they cannot be made out after the plants have been kept a few hours; if there is to be any doubt about any such character, that doubt can usually be settled by five minutes search for a good plant much more satisfactorily and more easily than by perhaps hours of hard work in the consideration of technical descriptions.

In general, notes treat of viscidity, hygrophaneity, and field-dryness of the pileus; of the colors of the lamellae, if they differ in color in young and mature plants; of the presence of milk and its color and taste; of noteworthy characters of the stem, as viscidity, the presence of a cortina and its color in young plants, and of an evanescent ring or volva; and of the special habitat of species growing on wood, under pines, in swamps, open pastures, etc. These notes are quickly made, as positive characters are the only ones usually stated, although in some cases specific statement of the absence of distinctive characters is very helpful. The field notes should be placed at once in the package with the plants to which they refer.

CARE OF PLANTS PREPARATORY TO IDENTIFICATION.—As soon as possible after reaching home or the place where the further work of determination and drying is to be done, the packages of fungi should be removed from the collecting basket and distributed in other covered baskets so that the packages may stand closely together on the bottom of the basket but not usually resting one on the other. In this distribution, the packages containing the most putrescent fungi, such as species of Coprinus, Psathyrella, Panaeolus, Boletus, Flammula, Tricholoma, Hygrophorus, and Amanita, may with advantage be placed in a basket by themselves, as they should be the first identified and dried, or many will be lost by decay. The packages of less putrescent fleshy fungi may be kept fresh in fair condition for two or three days after being collected, but the difficulty in their study and determination increases with the time they are kept.

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[3] Cf. Underwood: Suggestions to collectors of fleshy fungi. Alabama Agr. Exp. Sta. Bulletin 80:271. 1897.

Collecting the spores.— While distributing the packages from the collecting basket, at least one plant in each package should be set for spores, which may be collected very easily and without the sacrifice of a plant. Sheets of white paper and of black paper without a glossy surface are needed. If there is reason for believing that the plant bears white spores, a circular disk of the diameter of the pileus is cut with scissors from the black paper; this disk is then slit radially from the margin to the center, and enough of the paper is cut away about the center to give an opening of the diameter of the stem just underneath the pileus. The paper disk is then placed underneath the pileus in contact with it and with the stem passing through the opening made for it. The plant is then placed in erect position in the pile from which it was taken, and the other plants of the pile are arranged about this plant in such manner as to support it in erect position and also to hold the paper disk close up against the pileus. The four corners of the wrapping sheet are then brought together above the pile of plants and twisted together in the manner already described. The package of plants is then placed in the proper basket.

If the fungus is believed to have colored spores, the disk is cut from white paper. When the color of the lamellae causes doubt as to the color of the spores, set one plant for white spores and another for colored spores. In the case of species of Clavaria (exact knowledge of the color of the spores is necessary for specific determination in this genus) and of sessile and lateral stemmed pilei, it is merely necessary to lay one or more plants hymenial side downward on the spore paper in the pile and to enfold all again with the wrapper. The white paper may be obtained gummed and the spores will become imbedded in the adhesive matter, giving a spore print from which the spores will not be rubbed away.

More elaborate methods of collecting spores have been proposed.[4] The above simple method has been found to work well and to require but a small amount of labor and no bell-glasses to protect from currents of air. It has also the great advantage of keeping all the plants of a collection together.

DETERMINATION OF THE SPECIES.— In this connection, a statement which I made at our meeting of last year may be repeated: "When material is plenty, it is not usually worth while to determine for the first time dried specimens of the fleshy fungi. After one knows a species and has it in his herbarium, it is not difficult to recognize the species in dried specimens; but first determinations of fleshy Basidiomycetes and Ascomycetes are best made on fresh plants." During the night spores will fall on the paper disks in sufficient quantity to show their distinctive color. On the second day, therefore, one should proceed with the study and determination of as many as possible of his collections, and he can do so with the assurance that the unbiased observations made and the positive knowledge thus far gained will materially lessen the labor of his further study and contribute to the accuracy of his final determinations.

Many of the collections will be traced through to their species with but little trouble — this is especially true for the better known species of world wide distribution or of economic importance — and one will feel sure of the correctness of his determination. For such cases it is perhaps only necessary to add in addition to the usual data of specific name, date, locality, and details of local environment or habitat, a concise statement of the characters by which the plant is referred to the particular species, of the flesh and its color, taste, odor, and change of color when wounded, and of the characters already noted in the field notes. If the plants have been found to agree with a reliable plate of the species, record should also be made of the plate. In most cases these data may be given in the regular herbarium label, but in some instances it may seem best to use a larger slip.

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[4] HARZ in Botanisches Centralblatt — : 78. 1889. Translated in Jour. of Mycology 5: 163. 1889.

Difficulty will be experienced in determining some of the collections, or some collections may be referred to rare or little known species. In all such cases full descriptive notes should be made of all characters of the plants. These notes should treat of the pileus with regard to form, surface, moisture, color, hardness, and size; of the lamellae, tubes, or other hymenial surface with regard to relation to the stem, relative distance apart, connection with each other, waxy surface, surface studded with drops, color, form, and breadth; of the spores with regard to color, surface, form, and dimensions; of the stem with regard to structure, surface, coloration external and internal, form, dimensions, base, presence of a volva, ring or cortina, and its color and persistency; of the flesh with regard to color, taste, odor; of any change of color which any part may show on being cut or bruised; of the presence of milk and its taste and color; of the mode of growth of the plants, whether solitary, gregarious, or cespitose; of the kind of soil in which they grew or on what kind of wood, or other substance, and whether in woods and their kind, or in open fields; and also of locality and date; and of any other matter of which record seems desirable.

A suggestive outline for these full notes is afforded by the blank for collectors' notes in use by the members of the Boston Mycological Club. This blank also affords great help to the beginner by giving the usual scientific terms in which descriptions are couched.

An earnest attempt should be made to determine each species of which one makes an ample collection. From an ample collection one is not likely to conclude that an individual variation or abnormality is a constant character of the species. If the attempt at determination fails for the time being, the dried plants accompanied by full descriptive notes will usually make identification possible later on. Species not readily determined at the time often prove the prizes of the trip.

DRYING.—Well dried plants in ample amount, carefully prepared for the herbarium and accompanied by accurate notes of the characters of the fresh plants generally afford the most satisfactory specimens for the herbarium. If such specimens can be supplemented by photographs, sketches, drawings in color, sectional preparations, or specimens in alcohol, so much the better. In a few genera and one family, the Tremellineae, which dry poorly, alcoholic specimens are to be preferred, but in general well dried plants properly prepared are very satisfactory; they are convenient for reference also and do not occupy too much space.

A good herbarium specimen of a basidiomycete should show not only its external form, surface and habit but also its internal structure. Some plants should therefore be split lengthways into halves with a sharp knife or scalpel. If skillfully prepared one of these halves will show the thickness of the pileus, breadth of the lamellae, relation of the lamellae to the stem, structure of the stem, and sometimes the color of the flesh. Earth adhering to the base of the stem should be carefully removed, pains being taken to leave uninjured the whole base of the stem with its volva and radicated portions, when these are present.

The primitive mode of drying fleshy fungi is by the heat of the sun. This method gives good results with a few genera, but it is not available during the night and on cloudy days. At its best, it is so slow that thick, fleshy species of such a genus as Boletus become so decayed and so eaten by larvæ that the stem usually separates from the pileus and the tube characters become almost lost.

A better method is to place the fungi in a wire basket and suspend this above a stove. This gives good specimens if the heat is maintained night and day. During the summer the kitchen range is likely to be the only stove in which a fire is kept going. Now, many of the fleshy fungi which one will dry contain insect larvæ; as the plants dry out these larvæ literally drop from the frying pan to the fire. It is evident that the mycologist may encounter serious domestic obstacles in his attempts to use the range.

For some time I have been using a preferable method which I devised during my student days in order to save my collections. My Vermont collections of the last two seasons have been dried in a galvanized wire tray $14 \times 20 \times 2^{\mathrm{in}}$ deep (*fig. 2*). This tray is suspended horizontally 16^{in} above the floor against the side wall of a room by strong cords tied to the four corners of the tray and passing over a nail higher up in the side wall. As soon as a species has been determined, its characters noted, and the plants prepared as already directed, it is placed in a pile by itself, with its label, on the wire tray in the most favorable place available. An ordinary kerosene hand-lamp, total height 11^{in}, is placed under this pile of fungi of one species, or more usually under several piles grouped side by side, if several species are drying at the same time. The flame of the lamp is adjusted so that the current of heated air which rises up through the plants will not be hot enough to bake them. Species not subject to the work of larvæ, and which would make fine specimens by slow drying by sun heat, may be placed at places on the tray not directly above the lamp. As the piles of plants accumulate on the tray, more lamps are lighted and placed beneath it. Three lamps are sufficient for a tray of the area of mine. The lamps are kept going night and day until all plants on the tray are thoroughly dried.

During the process of drying the brittle stems of many species become pliant for a time. While in this condition it is a good plan to bend them near the point of attachment to the pileus so that they may lie in nearly the same planes as the pilei. Most species dry out rapidly in a few hours; others, as large Boleti and Lactarii, may require twenty-four hours, and may require turning once or more. As rapidly as plants are thoroughly dried in any piles, I remove such plants from the drying tray and place them, each species by itself, on the thick sheets of felt paper which are used as "driers" for flowering plants. During the busy collecting season my plants lie in the piles on these driers, from half a dozen to twenty species to a drier, in a room where they will not be disturbed. They may be stored temporarily in paper bags or boxes, one species collection to a bag or box, and with each is kept its label, notes, and spore print.

PREPARING THE ROUGH-DRIED PLANTS FOR THE HERBARIUM.—During the process of drying, many fungi bend and curl into very unnatural and irregular shapes. In their rough dried condition they cannot be distributed in the sheets of an herbarium. They have first to be moistened and then flattened and kept in that condition until they are dry again. This part of the work may be done at one's convenience.

I moisten the plants by placing them in a moist chamber, leaving them there until sufficient moisture has been absorbed so that they can be bent without breaking. I use for this purpose a dry goods case made of matched boards. The inside dimensions of the case are 27 × 20 × 16^{in} deep. It is large enough so that two dryers with their loads of dried fungi may be placed side by side in the bottom. Cloths dipped in water and wrung out so as not to drip, are hung in a curtain-like manner inside the case against the side walls. Another wet cloth is spread across the open top of the box and the board cover is placed over this. Most of the smaller species absorb sufficient moisture in two or three hours, but large species of Boletus, Lactarius, and Russula may need to be left in the moist chamber over night or even longer. A damp cellar will serve the purpose of a moist box.

In the pliant condition the stem and pileus may be bent by the fingers so that both lie in the same plane, and the pileus may be given a more natural form than it assumed in drying. Care must be exercised to do no violence to any part, nor to separate the lamellæ from the stem. When shaped for the herbarium, the plants must be prevented from curling in drying. This is accomplished by placing them in folded sheets of unsized paper between driers, placing these in a pile with the least weight on the pile sufficient to prevent curling. This is not *pressing* the plants, as that term is used with reference to flowering plants; it is simply preventing their curling out of shape while parting with the absorbed moisture. Pressure would crowd the lamellæ close together and crush them against the pileus, obliterating one of the most distinctive features of the fungus. In a well prepared specimen, unless the lamallæ are very broad, one should be able to look between them to the under surface of the pileus and make out venose connections if present.

If the plants are to be poisoned with a solution of corrosive sublimate or of strychnin, the poisoning should be done just before placing the specimens between the driers.

Mounting.—They will be dry enough for mounting after they have lain two or three days between the driers. Species sheets of standard size will be found preferable to half sheets for an herbarium of fleshy fungi. If the collection is small, it may be placed in an envelope of the Gray Herbarium style, and the envelope, bearing its label, should be glued to a card of somewhat larger size near its lower end (*fig. 4*, lower right hand corner). Sheets of mounting paper may be cut into halves, quarters, eighths, etc., for the cards. If the specimen is not scanty, two typical plants should be glued to the upper part of the card, one showing the upper surface of the plant and the other its under surface. These plants outside the packet facilitate comparison when referring to the herbarium, and they also catch the eye as one turns the sheets, and help to keep the species well remembered (see *fig. 4*, upper left hand corner).

The small card bearing the collection, part on the card and the remainder loose in the envelope, should be pinned to the species sheet at some place which will aid in keeping flat the pile of sheets of the genus. The several collections or specimens of the same species may be advantageously pinned to the same species sheet. If the collection is very large, a large envelope of the style used by Ellis in N. A. Fungi and Fungi Columbiani will hold the specimens from falling out better than the Gray Herbarium kind.

By this method the whole collection is kept together as a specimen in the herbarium. A specimen is not likely to be too ample. If some plants can be spared from it for exchanges.

they may be conveniently kept in the original collection until they are needed by others, and in the meantime they do not detract from its value for consultation. This does away with unmounted duplicates except in the case of large, woody Polyporeæ and Hydneæ.

Bulky specimens of Polyporeæ and Hydneæ and also collections of puffballs, etc., may be stored, each species or collection by itself, in small boxes of suitable size and the small boxes in larger boxes having the length and the breadth of a genus cover and a depth of 1¼, 2½, or a greater number of inches. These boxes are a great convenience. They may be kept in the regular pigeon-holes of herbarium cases, distributed among the families of which they contain specimens. In case of a specimen to be looked for in one of these boxes, a reference to the box in which it is kept should be given on the regular species sheet where one looks first.

SECTIONS OF FLESHY FUNGI.—In general, sectional preparations are regarded as of secondary value as compared with well dried and carefully prepared plants accompanied by good notes, but when well made and given in addition to the dried plants and notes, they add greatly to the value of the specimen. A full set of sectional preparations includes a median longitudinal section through a mature plant, the outer layer of the stem for the whole length of the latter but for only one-third of its circumference, the outer layer on the upper side of the pileus, and a spore print. If the plants are cespitose in growth, several median sections of different plants of a cluster will be grouped together. Median sections of young plants will also be needed in some cases to show inrolled margin of the young pileus, attachment of the veil, etc. The median longitudinal section of a mature plant is usually the most important preparation of the set. It must show faithfully the structure of the stem, the degree of attachment of the lamellæ or tubes to the stem, the breadth of the lamellæ or tubes, the thickness of the pileus, and the outline of the plant. No carelessness or inaccuracy in any respect, as, for example, omission of the stuffing of the stem, can be tolerated, as it makes the preparation directly misleading.

A thin-bladed knife or scalpel with a keen edge is used for cutting these sections, which must be cut very thin. The sections, as cut from the fresh plants, are arranged as naturally and artistically as possible on the gummed side of a rectangular piece of gummed paper just large enough for them. A piece of waxed paper such as florists and confectioners use is laid over the sections and it must also cover all the exposed gummed surface of the gummed paper. The combination of gummed sheet, sections and waxed paper is placed between sheets of light weight blotting paper and driers in a plant press and dried rapidly under heavy pressure. The sections adhere to the gummed sheet, retain their colors better than by any other method with which I am familiar, and do not shrink much in drying. When they are quite dry, the waxed paper may be lifted from the preparations and the gummed sheet. I glue the back of the gummed paper at the corners against the upper part of the card bearing the envelope of dried plants of the same collection, as shown in *fig. 4*, with the collection at the right hand corner of the species sheet.

Herpell[5] has given full directions in regard to preparing sections of fungi and he has also issued a fine set of such preparations.

PRESERVATION OF FLESHY FUNGI IN THE HERBARIUM.—The dried fungi may be poisoned with dilute solutions of corrosive sublimate or of strychnin by the methods in use for flowering plants. In Rep. N. Y. Mus. **24**: 43. 1869, Mr. Peck gave the formula for a solution of corrosive sublimate, sulfuric ether, turpentine and alcohol which he was then using on the specimens in the N. Y. State Herbarium. This solution has not worked well in use, and in its stead Mr. Peck kindly permits me to give his formula for a strychnin preparation which he is now using and finds more satisfactory in all respects.

[5] Präpariren u. Einlegen der Hutpilze fur das Herbarium. Berlin. 1880; Sammlung präparirter Hutpilze. St. Goar. 1881–1884.

Strychnin poison mixture :

Sulfate of strychnia.	⅛ oz.
Warm water	4 or 5 oz.
Alcohol	about 2 oz.

Dissolve the strychnin in the warm water ; add alcohol to the solution until the mixture becomes thin enough to spread easily and to penetrate the specimens. The simple aqueous solution is not absorbed readily or spread easily, manifesting a tendency to gather in globules like mercury. The addition of the alcohol overcomes this difficulty.

A thorough application of the poison should be made with a soft brush to every portion of the surface of each plant. The application can be made with the least labor when the moistened plants, after being shaped for the herbarium, are about to be placed between the driers. As the poison does not penetrate to any great depth, "moth balls" (napthaline, camphorine, etc.) are often placed in the boxes with specimens of very thick and bulky fungi, such as species of Fomes and the like, to keep away insect visitors.

My herbarium of fleshy fungi is stored in insect proof tin boxes. These boxes (*fig. 3*) are large enough to take genus covers and mounting sheets of the full standard size; they are 6^{in} high—larger than the usual herbarium pigeonhole, but this is an advantage as some genera are very bulky. These tin boxes have a well made drop door at the front end, which fits so well as to retain vapors of carbon bisulphide in the box for fully forty-eight hours. The boxes are kept in a herbarium case.

When my herbarium was transferred to these boxes, a small saucer containing about 5^{cc} of carbon bisulphide was placed in each on the pile of plants it contained. At the end of three days the saucers were removed. There has been no evidence of further insect work in the contents of these boxes. Since that time all the collections of the season and all specimens received by exchange are subjected to the vapors of carbon bisulphide for at least forty-eight hours before being distributed in the herbarium. I find the chief drawback to this method of storing a herbarium of fleshy fungi to be the great expense of the tin boxes, of which I now have forty-two in use. To make space for future additions, I think of poisoning a portion of the herbarium, consisting of groups of genera least troubled by insects, and keeping this portion in the ordinary herbarium pigeon-holes.

MIDDLEBURY COLLEGE, MIDDLEBURY, VT.

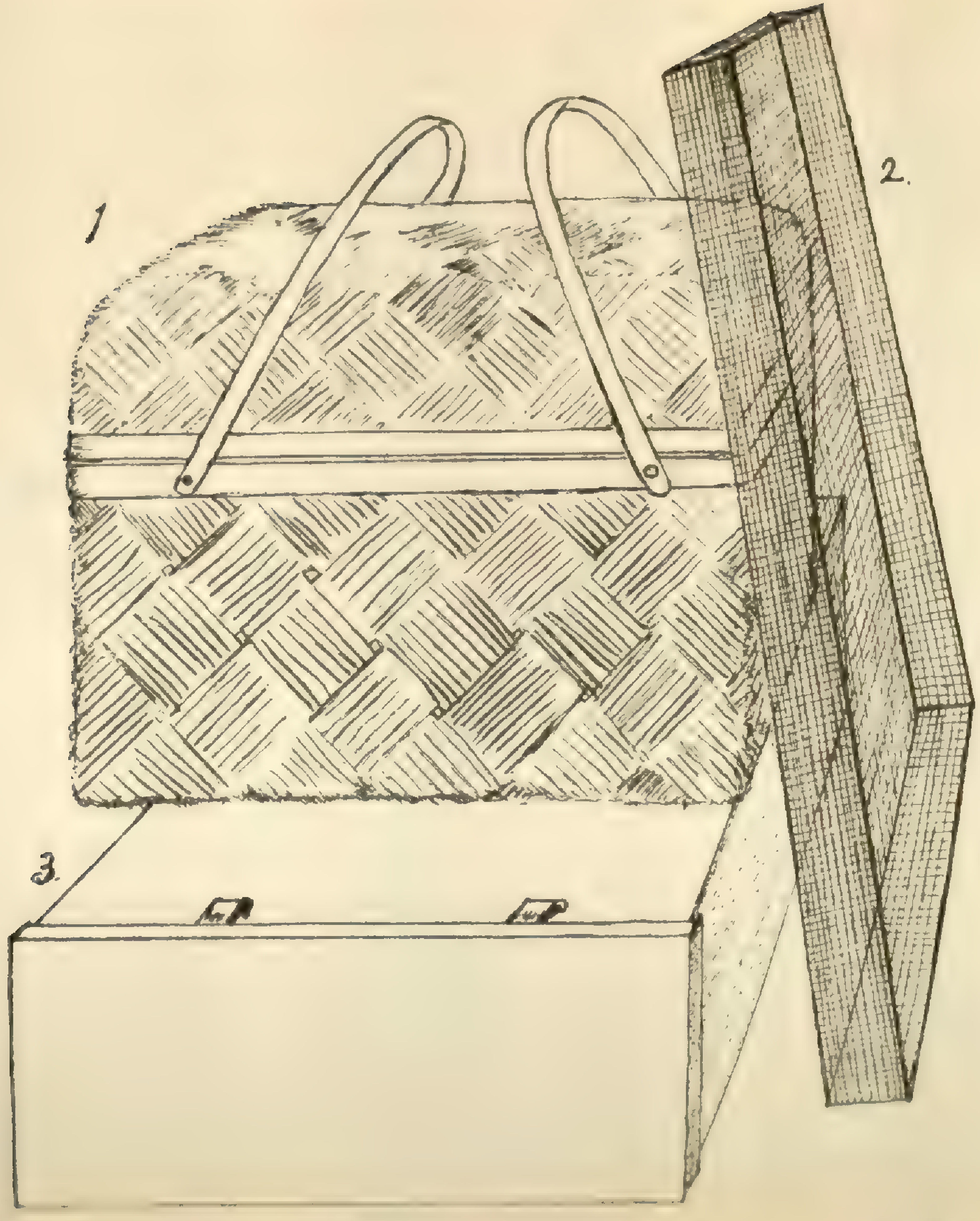
EXPLANATION OF PLATE XIV.

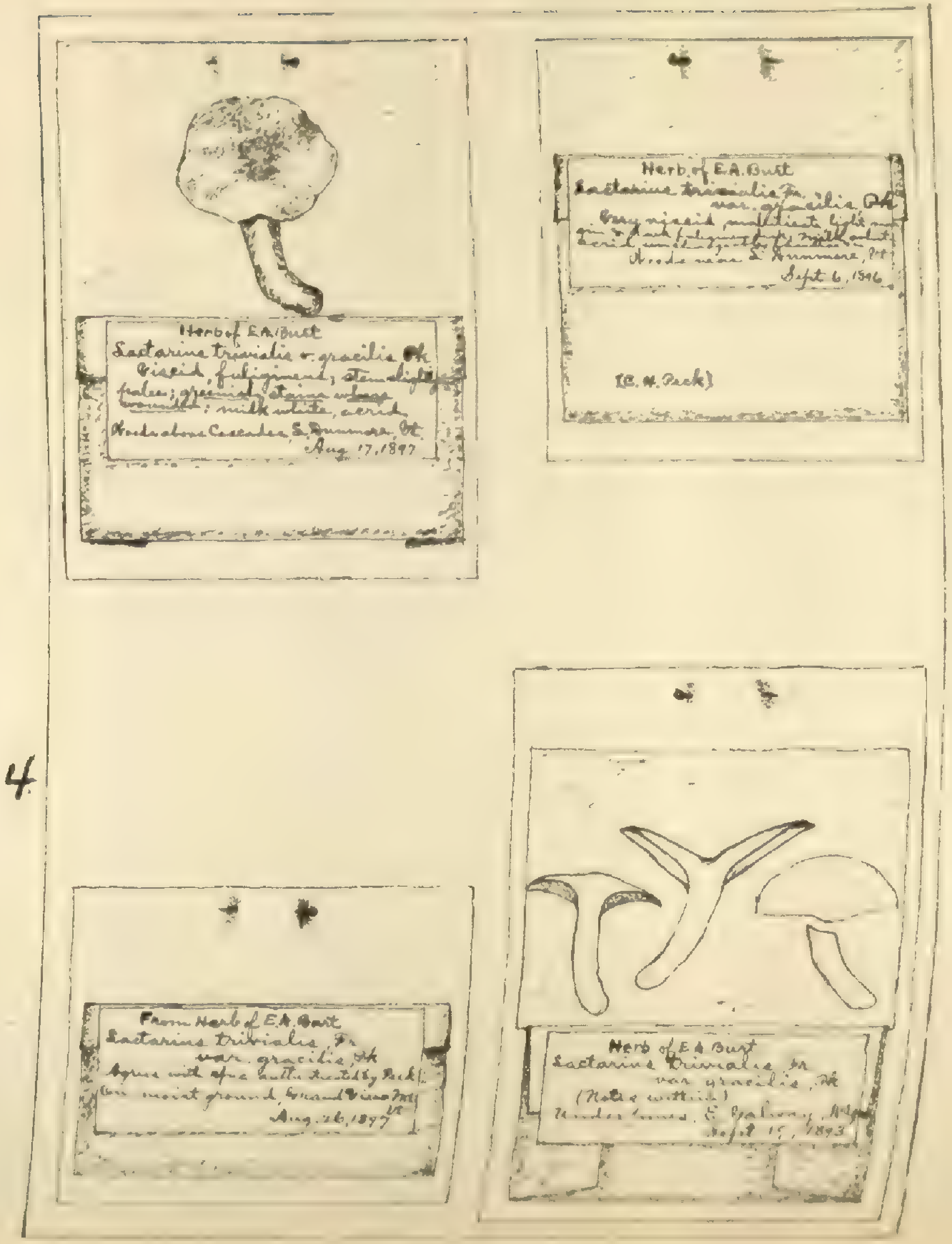
FIG. 1. Collecting basket.

FIG. 2. Drying tray of galvanized wire of ¼ in mesh.

FIG. 3. Insect-proof tin box for storing the mounted fungi. This is intended to take the place of the pigeon-hole in an herbarium case.

FIG. 4. Sketch of a species sheet of *Lactarius trivialis* Fr. var *gracilis* Pk. from my herbarium, showing four collections each mounted on a card and the cards pinned to the sheet. The plants of each collection are loose in their respective packets, with the exception of that at the upper left hand corner of the sheet where one plant has been mounted outside the packet on the upper part of the card, and with the exception of the collection at the lower right hand corner where a set of sectional preparations on gummed paper is mounted on the upper part of the card.


1
2.
3.


4.
Herb of E.A. Burt
Lactarius trivialis v. gracilis Pk
Viscid, fuliginous; stem slightly
scaly; [illegible] staining when
wounded; milk white, acrid.
Woods above Cascades, E. Dummerston, Vt.
Aug. 17, 1897
Herb. of E.A. Burt
Lactarius trivialis Fr.
var. gracilis Pk
[illegible]
Woods near E. Dummerston, Vt
Sept 6, 1896
(C. H. Peck)
From Herb of E.A. Burt
Lactarius trivialis Fr
var. gracilis, Pk
Agrees with [illegible] by Peck
On moist ground, Grand View Mt.
Aug. 26, 1897 Vt
Herb of E.A. Burt
Lactarius trivialis Fr
var. gracilis, Pk
(Notes within)
[illegible] E. Galway, N.Y.
Sept 15, 1893

[illegible]

ON SOME ASPECTS OF VEGETABLE PATHOLOGY AND THE CONDITIONS WHICH INFLUENCE THE DISSEMINATION OF PLANT DISEASES.

W. C. STURGIS.

THE modern vegetable pathologist finds himself confronted at the very outset of his investigations by many preliminary questions which he is obliged to answer more or less satisfactorily before he can recommend with any degree of certainty a definite line of preventive or curative treatment.

He must be familiar with the main principles of vegetable physiology in general and the normal anatomy and histology of the special plant under consideration, in order that he may decide when and how the general course of the physiological activities of the plant is disturbed, and whether the structure which he observes is normal or otherwise. In case the anatomy is evidently morbid, he must be prepared to diagnose the case with as great a degree of accuracy as possible. Let us suppose that, as a result of extended observations upon one plant or a series of plants showing similar symptoms of disease, he finds that a particular organism is generally or constantly associated with the disease. I pass over the large class of cases in which no such organism is observed, and in which therefore the pathologist must put all his knowledge to the test, examine the environment with the utmost attention to detail, exhaust all his resources, and test every possible theory in his search for operative causes.

But, having found a possible connection between the diseased condition under observation and a living organism, the arduous portion of his work begins, viz., the determination of the parasitism or the mere saprophytism of the organism in question. For it is not enough merely to observe the association of a living organism of fungous or bacterial nature with the diseased condition, no matter how intimate or constant such association may be. Of course, there may be cases, such as the "black-knot" of plum trees, in which the effect of the fungus is so apparent and its parasitic nature so manifest that the evidence of the unaided eye is almost conclusive (though even in this case it will be remembered that for years the knots were supposed to be caused by insects), but in the vast majority of cases a far more searching proof is necessary. The organism whose parasitic nature is in question must be isolated from its host and grown in a pure culture; thence it must be transferred with due care to the uninjured tissues of a healthy plant of the same species as that from which it was derived, growing under normal conditions; in this plant it must produce symptoms of disease identical with those originally observed; and, finally, from this plant the same organism must again be isolated. Only under the fulfillment of such conditions can an organism be stamped as an absolute parasite.

These are rules made familiar to us by the methods of modern bacteriology, but they too seldom enter into the practice of the vegetable pathologist. It may be said in passing that their fulfillment cannot always be attained. It is more than probable that only an extremely small proportion of the diseases of plants which are commonly attributed to fungous parasites are absolutely parasitic in their nature—that is, due to organisms which can attack and penetrate the uninjured tissues of healthy plants growing under normal conditions, and live therein at the expense and to the detriment of the host. In most cases the pathologist must be prepared to search for injured tissues offering an opportunity for saprophytic, followed possibly by parasitic attacks, or for unfavorable surroundings weakening the plant or rendering it peculiarly susceptible to the attacks of semiparasitic organisms. Such conditions are easily induced, and great care has to be exercised in drawing conclusions from results obtained in the laboratory or greenhouse from inoculations of wounded tissues of plants kept under conditions of warmth and moisture which seldom, if ever, obtain in the field. The pathologist must be prepared to ascertain and to correct the predisposing as well as the apparent causes of disease, and among such causes he may even be forced to include the long process of artificial selection which has had as its almost exclusive aim the development of plants along lines of fruitage only, with too little regard to those factors which tend to produce hardy stock resistant to unfavorable conditions.

I make these statements with some hesitation, yet I believe them to be borne out by facts. It is becoming more and more apparent that in combating the host of fungi which invade our orchards and truck farms in these days of intensive farming, due regard must be paid to what we may call the hygiene of plant life. The proper regulation of the water supply by drainage and tillage; the securing of the free access of air and sunlight by pruning, thinning, and training; care in the selection of healthy, resistant stock; the intelligent use of fertilizers and their adaptation to the needs of the plant—these are some of the sanitary measures which, duly considered and acted upon, will do more than the mere use of fungicides to insure success in dealing with fungous diseases.

To take individual proofs of these general statements: Experiments recently conducted at the Rhode Island Experiment Station have gone far to show that the two most serious diseases of celery are due, not primarily to the attacks of the fungi associated with them, though both of them might properly be placed among Sorauer's "Schwäche-Parasiten," but to a weakening of the plants attributable to the purely artificial level method of culture whereby the roots are exposed to all the temperature-changes of the surface soil. A mulch, consisting even of the leaves of diseased celery teeming with the spores of the fungi in question, served to prevent the spread of the disease. That proper attention to purely cultural conditions will very largely decrease the prevalence of apple "scab" is a matter of common observation, and I have myself seen a peach orchard, showing the first symptons of a serious attack of *Cercospora Persica*, completely restored to health by tillage and a judicious application of nitrate of soda. I would direct the attention of every vegetable pathologist to the words in which Professor Bailey summarizes one of his bulletins on the care of orchards, and to the order of the terms which he uses, "Till, feed, prune, spray." I have outlined the steps which the vegetable pathologist must take in order to secure a trustworthy diagnosis. Having learned to distinguish a morbid condition through a working acquaintanceship with normal physiology and anatomy, he must determine the final cause of disease; by careful investigation he must decide whether it is parasitic or otherwise, and, if so, in what degree; and he must determine whether the attack of the parasite is immediate, or superinduced by the local destruction of tissues or by the general debility of the plant.

One very important question remains to be considered, viz. When and how the parasite, if such it be, secures entrance to the host and is thence disseminated. Upon the answer to this question depends in great measure the whole philosophy of preventive treatment. One method of determining the matter is, of course, the careful study of the life history of the fungus in question. If it be known, with a reasonable degree of certainty, that a certain pathogenic fungus depends largely upon aerial summer-spores for its dissemination, we naturally recommend preventive treatment with fungicides; if it is a perennial mycelium to which the fungus owes its continuous vitality, we are prepared to advise pruning. If it is ascertained that certain spores, seemingly delicate, are enabled to pass uninjured through an animal's digestive tract, the manure heap demands our first attention; and if careful research in the field and the laboratory is at length rewarded by the discovery of resistant spores produced during the winter in or upon the refuse of a diseased crop, we very properly lay the utmost stress upon a thorough cleaning up and destruction of all such refuse. A knowledge of such facts connected with parasitic fungi is absolutely essential to any intelligent application of preventive measures, and we cannot value too highly such researches as those of Thaxter upon "potato-scab," or of Aderhold upon the ascosporic forms of *Fu*-

cladium dendriticum, and *F. pyrinum*. But fruitful results are also to be obtained by observations upon the direct means by which the reproductive bodies of parasitic fungi are borne hither and thither and become fresh sources of contagion.

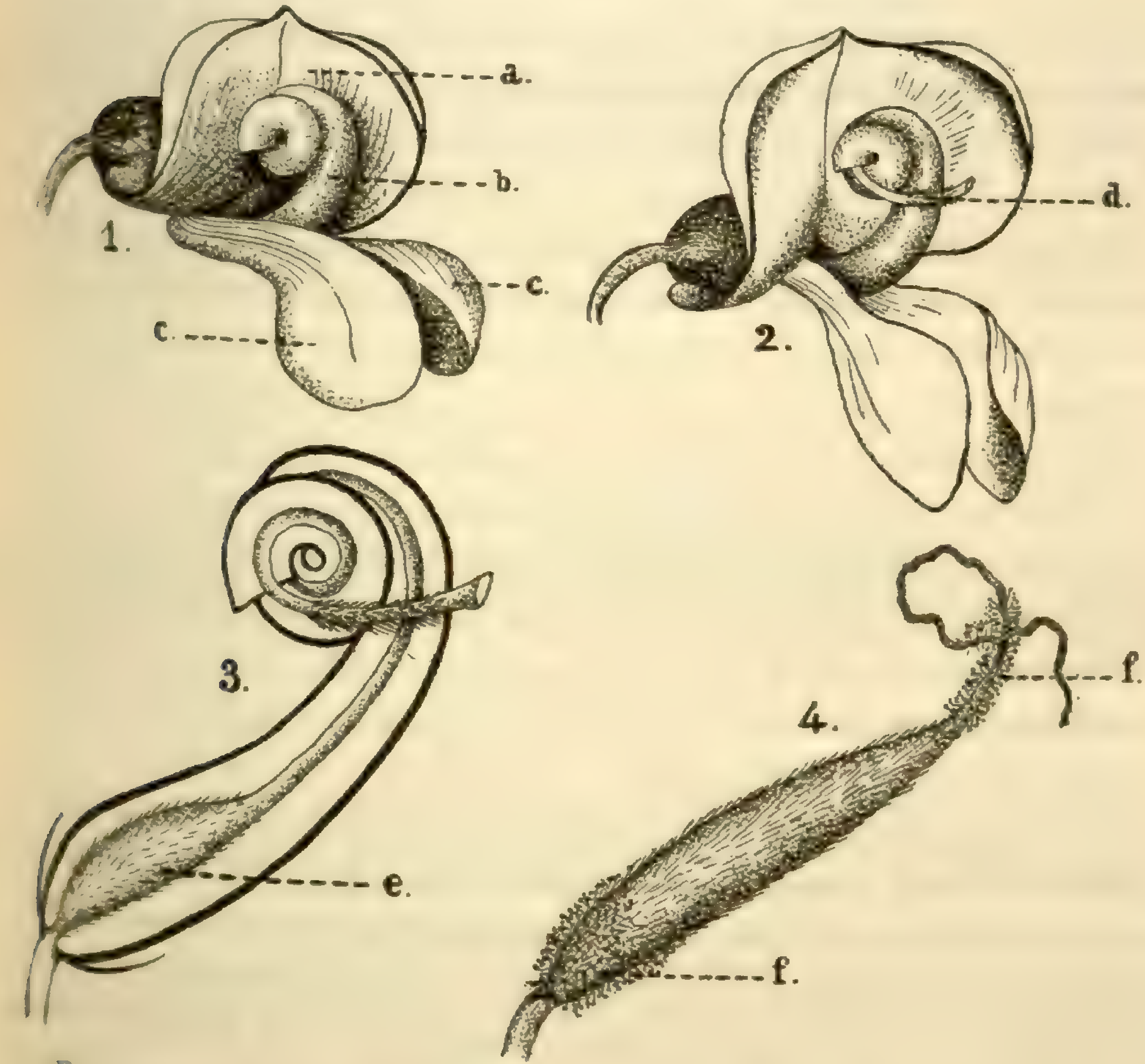


FIG. 1.—Normal flower of lima bean.
FIG. 2.—The same, with wing-petals depressed and style protruded.
FIG. 3.—Section of keel, showing the ovary and protruded style.
FIG. 4.—Young pod, showing mildew at the two extremities.

This leads me to speak of a rather striking case which came under my observation during the past summer. For several years the growers of lima beans in southern Connecticut have suffered great losses through the destructive attacks of the mildew, *Phytophthora Phaseoli* Thaxter. This fungus attacks the pods, sometimes covering them with its white, felt-like mycelium; it also occurs upon the leaves, though rarely and inconspicuously, and upon the fruiting branches where it does extensive injury by destroying the tissues below the flowers, thus causing the death of a the young pods above the point of attack. Before proceeding farther let us recall the structure of the bean flower. It w be remembered that the pistil and the stamens are complete enclosed in the spirally coiled keel (*fig. 1*). No portion of them is exposed to view except the very base of the ovary, and that only when the surrounding petals are forced apart. Under these conditions not only would close-fertilization seem to be assured, but it would appear certain that, however the mildew gained access to the host, it certainly could not be by infection of any part of the pistil before the fall of the flower. Yet, continuous observation convinced me that the mildew failed to appear to any serious degree before the flowers began to expand; that fairly mature pods seldom showed areas of fresh infection; that the young pods often showed a copious growth of fruiting hyphæ and spores indicative of infection before the fall of the blossom, and that the points of infection were always at the extreme base or tip of the young pods. These observations led to the supposition that insects were mainly responsible for the dissemination of the mildew.

Further investigation confirmed this view. I have called attention to the enclosed and protected position occupied by the pistil; this obtains until the flower is visited by an insect of considerable size, generally a honeybee. The projecting wing-petals offer a convenient landing place, and, as the bee alights on them his weight deflects both wings and keel, the style is protruded from the keel, the bee's abdomen brushes over it, and in his efforts to reach the bottom of the flower the petals are forced apart, the base of the ovary exposed and the bee's head comes in contact with it (*figs. 2, 3*). Thus cross-fertilization is secured, but if the bee has, by chance, touched a mildewed pod with either head or abdomen, fungous infection no less surely occurs. It will be noted that the only portions of the pistil touched by the bee are the base of the ovary and the style. An examination of scores of flowers showed that in the majority of cases they were infected, and in these cases, without exception, the points of infection were identical with the spots touched by the bees (*fig. 4*). One additional point might be mentioned. On a very badly diseased plantation it was noticeable that the spread of the mildew practically ceased about September 10, although the vines continued to flower and produce pods until October. I am at a loss to account for this sudden cessation of fungous activity, but it is worthy of notice in this connection that after the date above mentioned hardly any bees were seen in the plantation.

It seems almost certain then, that in the case of this mildew at least, insects are the principal agents in the dissemination of the fungus.

But I have already stated that the fungus sometimes appears elsewhere than upon the young pods. In some cases it is apparent from the respective positions of old and fresh points of infection upon the leaves or mature pods that the spores have been carried by the rain or dripping dew from one portion of the vine to a subjacent one, but certain facts led me to think that the wind played a considerable part in the infection of older tissues. In order to test this matter I pursued the following course. The mildew is usually confined to comparatively low, damp situations. The grounds of the Connecticut Experiment Station occupy an elevated position, the land is well drained, the soil light and sandy, and so far as I know, lima beans on this land have never mildewed. During the past summer they occupied two rows running east and west. Directly south of them, at a distance of about 100 feet, were two rows of bush limas running north and south (*fig. 5*). On August 14, when the mildew had been abundant for a month or more on a farm at a distance of about a mile in a straight line from the Station, the Station vines were carefully examined and found to be perfectly free from mildew. The following day two mildewed pods were brought from the farm above mentioned, and the mildewed surface of one of them was rubbed upon a single healthy and almost mature pod at the east end of each row of pole limas. The prevailing winds at the time and for the ten succeeding days varied from northwest to northeast. Within a week the mildew appeared abundantly upon the two infected pods and from this point swept down both rows from east to west, and in two weeks the crop was practically ruined. Meantime the two rows of bush limas were examined daily. About ten days after the first infection of the pole limas, mildewed pods were found upon the bush limas, but only at the north end of the

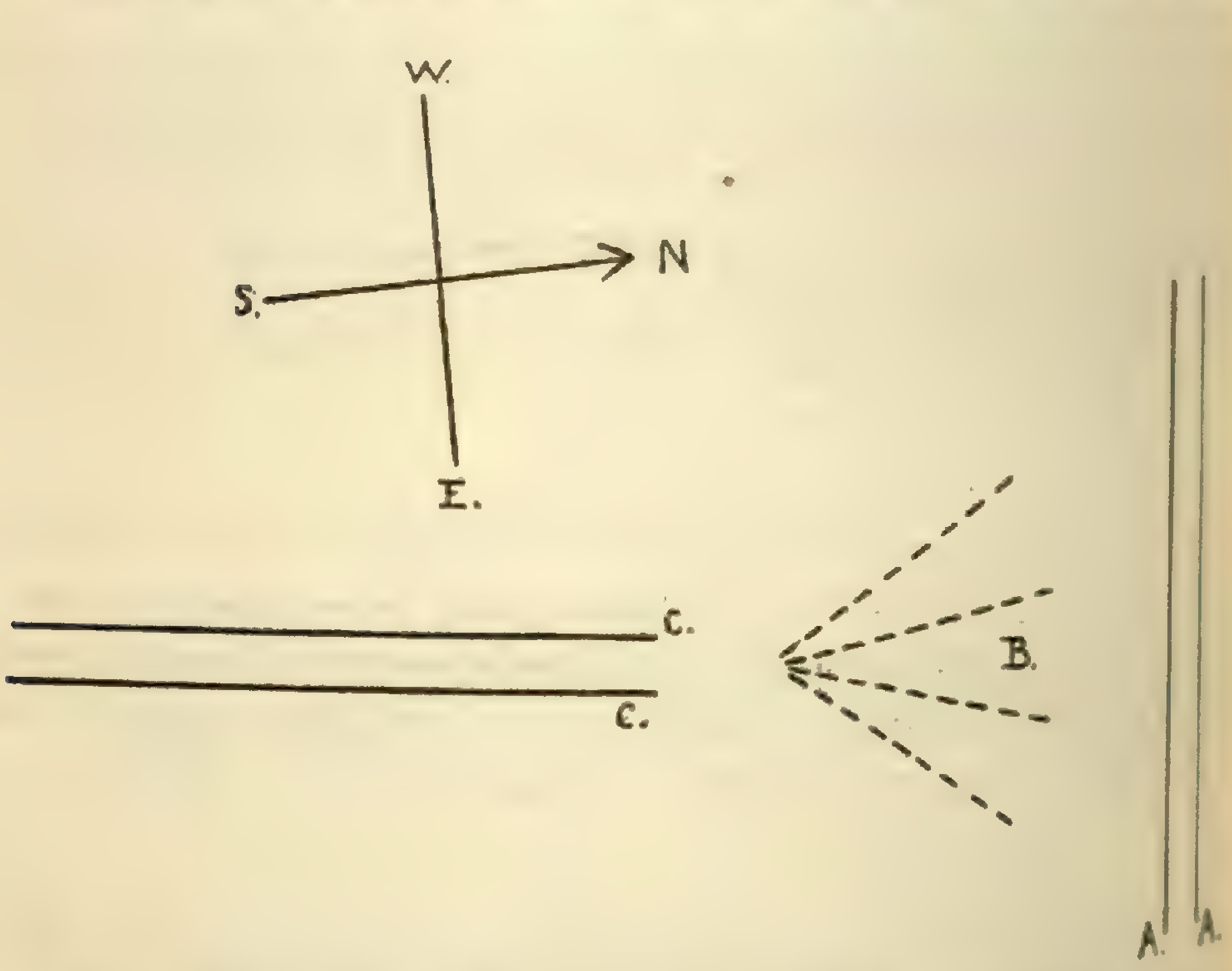


FIG. 5.—*A*, *A*, points of primary artificial infection on pole beans; *B*, course of prevailing winds; *C*, *C*, points of secondary natural infection on bush beans.

rows nearest to the source of infection. From this point it spread rapidly southward until both rows were completely involved.

The conclusion seems inevitable that not only do insects play an important part in the dissemination of fungous diseases but that the wind certainly does its share.

How this particular fungus is propagated from season to season is a question of great importance, but it is apart from the object of the present paper which is to call renewed attention to the divers lines along which the vegetable pathologist is obliged to direct his attention, and the importance and interest which attaches to all observations relative to the dissemination of fungous diseases.

AGRICULTURAL EXPERIMENT STATION,
New Haven, Conn.

BRIEFER ARTICLES.

POTAMOGETON ROBBINSII.

(WITH PLATE XV)

THIS pondweed, first described by Oakes in 1841, is the rarest of the North American species to fruit, unless we except *P. interruptus* Kitaibel, which bears floral spikes quite freely, but is not known to mature fruit in this country, though it does in Europe. The principal mode of propagation of *P. Robbinsii* is by fragments of the stems, which root freely in the muddy bottoms of ponds and lakes where it grows, often forming dense patches covering considerable areas. Dr. Thomas Morong writes with regard to its fruiting as follows: "Very rarely, in years when the waters are low, the flowering spikes rise above the surface and perfect a few fruits. Dr. Robbins never saw but one fruit, which was collected many years ago in Oregon by Hall, and this was split in two, Prof. D. C. Eaton taking one half and Dr. Robbins the other. In the year 1880 Mr. Faxon had the good fortune to secure a few fruiting specimens in Jamaica Pond, Massachusetts. Besides them I have never known another instance, although the plant is very prolific in the localities where it occurs.[1]"

It was my good fortune in 1889 to find it fruiting in the Chesago lakes, Centre City, Minnesota, and a number of specimens were secured. This was in early September. Twice before during the same season plants were collected in the latter part of July in northern Michigan, at Republic, and in Goose lake near Negaunee. The specimen from Republic has a spike of fruit well formed, but immature. The superiority of the fruiting plants from the Chesago lakes, compared to those hitherto figured, has led me to have the accompanying plate prepared. It very accurately represents the average of the fruiting or upper parts of the stem, the lower very leafy portion, or that of barren shoots, not being represented. The specimens show an inflorescence loosely paniculate, the fruiting portion of the stems being 10 to 15^{cm}

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[1] The Naiadaceæ of North America, Mem. Torr. Bot. Club **3**: 54. 1893.

long, generally with four to nine or ten spikes. Some spikes get no farther than the floral stage. On others from three to six nutlets ripen, part of the flowers on them being aborted. One stem with eleven spikes in various stages of development had seven with perfect fruit, though not fully grown in all, aggregating about twenty-five nutlets. The largest number on a single spike is six. The spikes are $2–3^{cm}$ long, on slender diverging or erect-spreading grooved and angled peduncles, which are $3–7^{cm}$ (mostly $3–4^{cm}$) long. The nutlets are $3–4^{mm}$ long by $2.5–3^{mm}$ wide. They are brown to reddish-brown in color, the surface minutely roughened under a lens. They are three-keeled on the back, the prominent middle keel having a thin, sharp, slightly angled margin. There is a shallow central depression on each side, circular, or a little elongated longitudinally, with a diameter about one-third that of the body of the nutlet. The plants grew in shallow water, the upper parts of the inflorescence usually protruding above the surface. I am indebted to Mrs. Agnes Chase of Chicago for the drawings, which faithfully represent the specimens.—E. J. HILL, *Chicago.*

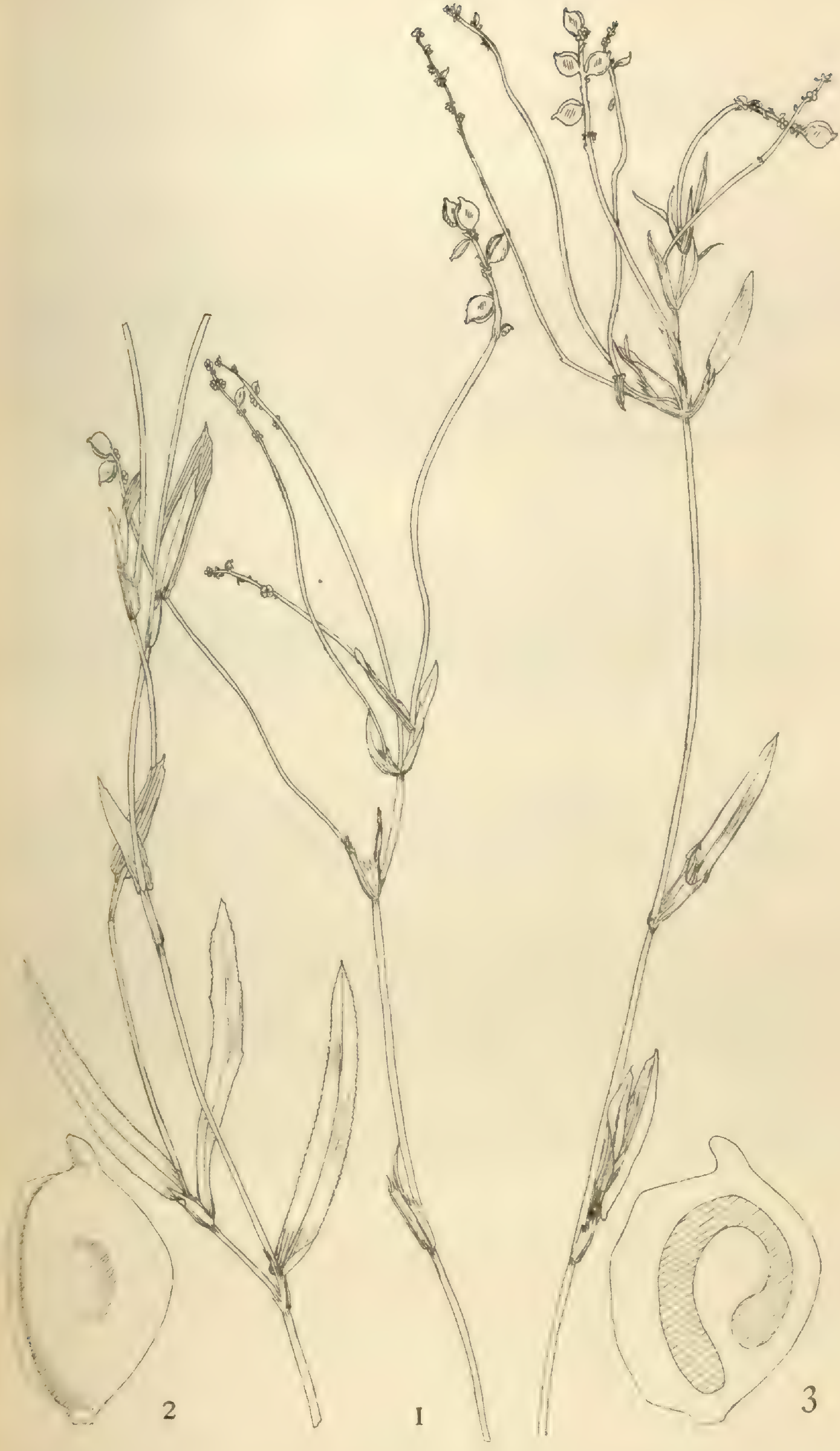
EXPLANATION OF PLATE XV.

FIG. 1. Upper portion of a fruiting stem, natural size.
FIG. 2. Fruit enlarged ten diameters.
FIG. 3. Section of fruit, showing embryo, enlarged ten diameters.

WYOMING JUNIPERS.

THE junipers of Wyoming, while not numerous, are interesting. Until recently these have been assumed to be all of one species, *Juniperus Virginiana* L. The common Rocky mountain form of this has recently been segregated by Dr. C. S. Sargent under the name of *J. scopulorum.* This species seems to require two years to mature its fruit, this fact being one of the points upon which, as I believe, this good species is founded.

Some other species of Rocky mountain juniper were known to be common in neighboring states, *J. occidentalis* Hook. to the northwest, *J. Californica Utahensis* Eng. to the west, and *J. occidentalis monosperma* Eng. to the south. That one or more of these may yet be found within the borders of this state is quite probable; in fact, when during 1897 a



HILL on POTAMOGETON ROBBINSII.

form common in the hills of the Red Desert was secured it was assumed to be one of the above-mentioned well-known species. In trying to name the specimens, however, it soon became evident that none of the extant descriptions would apply. To make sure that such was the case I secured from other localities material of closely allied forms, more especially *J. occidentalis monosperma* and *J. Californica Utahensis*.[2] The specimens agreed no better than the descriptions. *J. occidentalis monosperma* was excluded at once by its fleshy berry and small pointed seed. The new form was likewise to be distinguished from *J. Californica Utahensis* by difference in color, size, and shape of berry and especially by the seeds; also by the larger, plumper leaves. These differences are more or less well shown in the accompanying cut, where a bit of twig, some berries and seeds of the two are similarly placed and photographed (enlarged) on one plate as nos. 1 and 2 respectively.

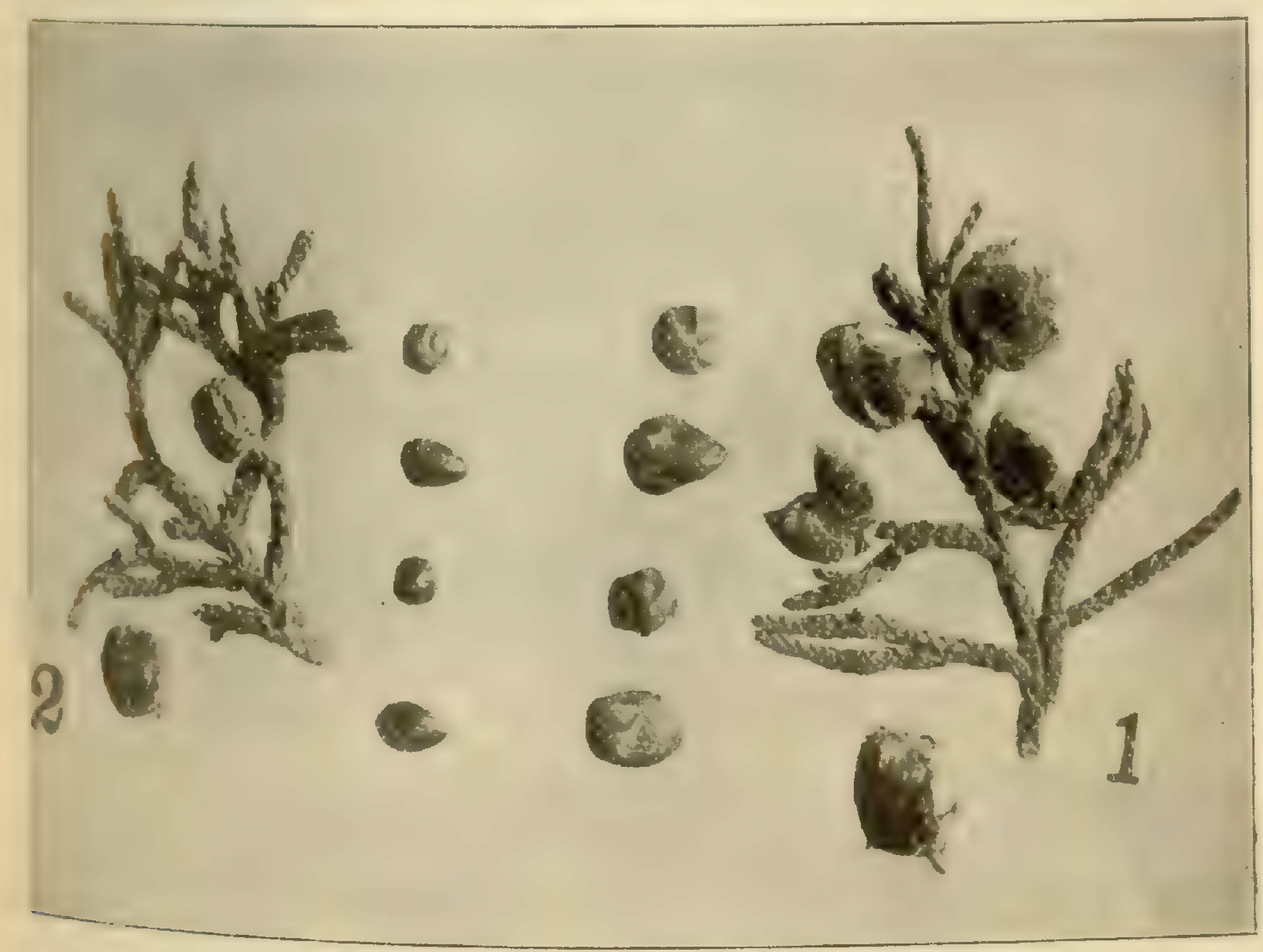


FIG. 1.—*Juniperus Knighti* Aven N. (1) and *J. Californica Utahensis* Engelm. (2).

The new form (no. 1) has not only the larger seed, but its obtuse only slightly grooved apex and its rounded swollen base will distinguish it from the other with its smaller, acute, brown-tipped seeds. Since it does not seem possible to place this with any of the already described forms, it may be named and characterized as follows:

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[2] For specimens and loan of specimens I am indebted to Messrs. T. S. Brandegee, J. G. Lemmon, and C. V. Piper.

Juniperus Knighti, n. sp.—A scraggy shrub or small tree, usually much branched from the base, *i. e.*, trunkless or breaking up into several subequal trunks also freely branched, branches widely spreading, the lowest close to the ground and almost resting upon it, round-topped, 3–7^{m} high or possibly in places exceeding this: leaves three-ranked, closely appressed, of rhomboidal outline, subacute, about 1^{mm} wide, nearly twice as long, thick, sometimes slightly depressed on the dorsum, entire or rarely minutely denticulate, neither pitted nor glandular, persisting in part on the branches of old trees as dead somewhat acute or acuminate scales, branches of young trees almost smooth or with a few long-acuminate scattered scales with usually a whorl of the same at the base of the branchlets; the branches divaricate but not squarrose: peduncle or fruiting branchlet short and thick: berry-like cones blue-green or copper colored (all distinctly copper colored if boiled), distinctly marked on the surface by the apices of their several scales, broadly oval, 7–10^{mm} long, dry, the coalesced scales thin, in dried specimens closely and tenaciously adherent to the large single seed: seed ovate, obtuse, slightly grooved above, rounded or swollen at the base: fruit possibly not maturing till the second year. —Type specimen, Herb. Univ. of Wyo., no. 3096, Point of Rocks, June 1, 1897.

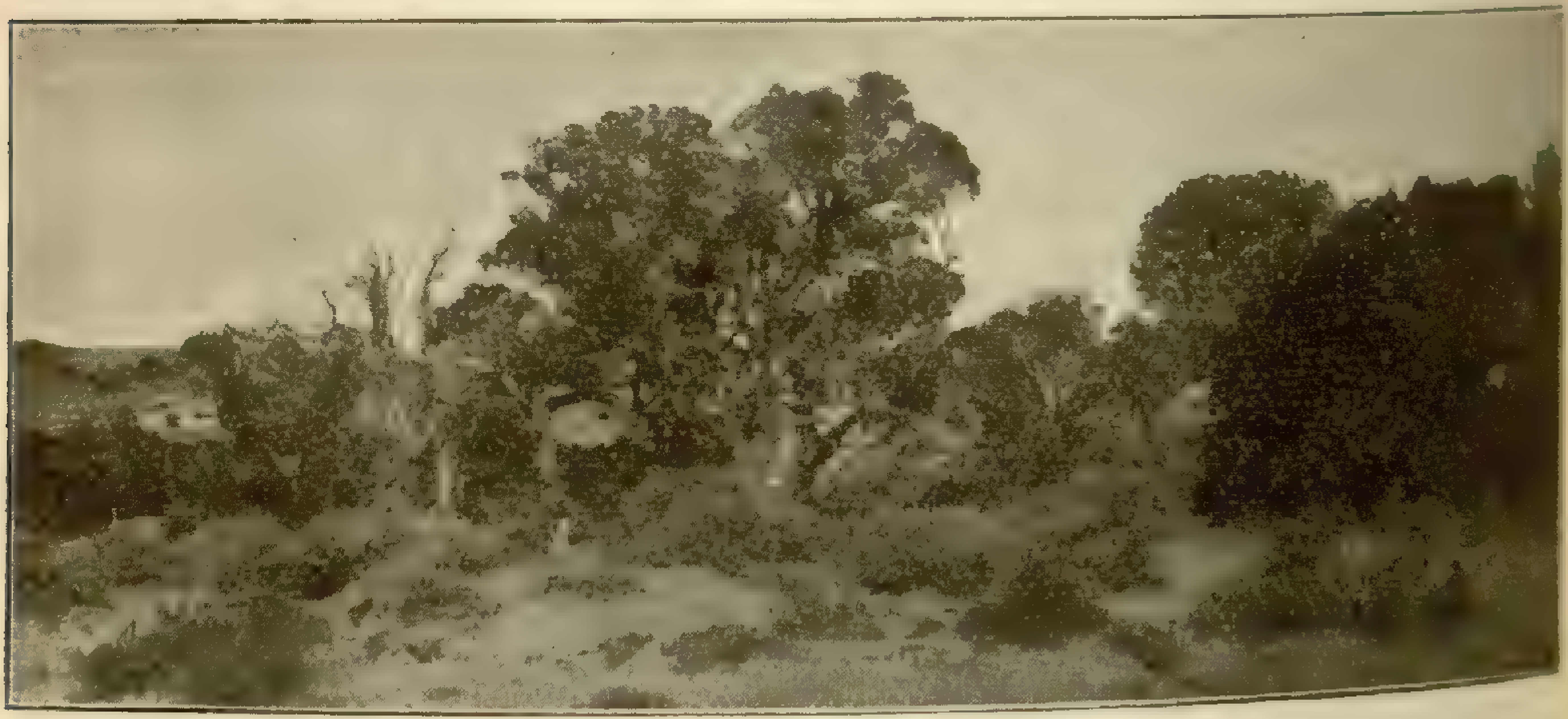

FIG. 2.—*Juniperus Knighti* Aven N.

It is with pleasure that I dedicate this species to Professor W. C. Knight, geologist and palæontologist and whilom botanist, to whom I am often indebted for specimens, and who first called my attention to this form.

This shrub-like tree is common in the so-called cedar bluffs, red sandstone hills, occurring at intervals throughout the Red Desert region of Wyoming from the Seminoe mountains to Green river. It was observed by the writer in numerous localities during the summer of 1897, the accompanying figure being from a photograph secured at Point of Rocks. The habit as shown is not only characteristic but nearly universal. One is reminded of the recently published illustration of Dr. Sargent's *J. scopulorum*,[3] which is scarcely characteristic of that species as I know it in the hills about Laramie.

The two foregoing are the only tree-like junipers that have yet been secured in the state, but one or two others may possibly be found within our borders to the west and north. Of the shrubby forms the following are abundant: *J. communis* L., *J. communis Sibirica* (Burgsd.) Rydb., and *J. Sabina* L.—Aven Nelson, *The University of Wyoming.*

THE MORPHOLOGICAL SIGNIFICANCE OF THE LODICULES OF GRASSES.[4]

The question of the morphological significance of the lodicules in the grasses has been discussed by very many botanists during the last hundred years. The last author, of which I know, to deal directly with the subject was Dr. Edward Hackel, the eminent agrostologist, who in his paper published in the first volume of Engler's *Botanische Jahrbücher* (1880), treats the question so exhaustively that his conclusions, supported as they are by his careful researches and to some extent no doubt by his great reputation as a student of the grasses, have for more than twenty-five years been accepted as the true interpretation of these organs. A glance at his historical résumé shows that, in the main, two views have been held by botanists: first, that these organs constitute a rudimentary perianth, to which view a considerable number, especially of the older botanists, gave adherence; and second, that they are remnants of bracts in morphological value the equivalent of leaves. To the latter view Hackel, as well as other earlier writers, held.

[3] Garden and Forest 10: 423. 1897.

[4] Read at the Ithaca meeting of the Society for Plant Morphology and Physiology.

It is important at the outset to point out that in other orders of monocotyledons the problem would be less important and indeed less easy of solution, since there frequently occur in them species exhibiting a complete transition from the bracts of the flower cluster to the leaves of the perianth. In the grasses, however, the true leaves are always distichous, while the sporophylls of the gynoecium as well as the androecium are in threes. The interpretation must mainly depend then upon the demonstration of the trimerous disposition of the lodicules on the one hand, or on their distichous arrangement on the other.

Either interpretation may presuppose the suppression of whole whorls or of parts of whorls or of bracts; the union of parts of the same set; the adhesion of superimposed sets or superimposed leaves. Hackel studied first the development of the lodicules on a considerable number of species, mostly European; second, he made a comparative study of mature lodicules; and third, he studied their anatomy. His conclusions are as follows:

1. "The anterior lodicules are to be regarded as the lateral halves of a leaf alternating with the palet (Vorspelze), the middle part of which only in rare cases develops either partly or entirely.

2. The anterior lodicules, arising as they do from a single simple rudiment (Anlage), experience in their growth various arrests through the more rapid growth of neighboring organs; they develop very often on their posterior border outgrowths in the form of teeth and lobes which, taken together with the before mentioned conditions, lead sometimes to the lodicules appearing dissected into distinct and even into superimposed lobes, whereby the appearance is sometimes presented of an aggregation of lodicules from separately inserted leaf structures.

3. The anterior lodicules are independent of the palet, although they sometimes unite mechanically with its margin, however, without organic union; they too develop later; are inserted higher on the axis than the palet; and in their tissue structure differ widely from it. The delicate bundles of the lodicule do not unite with those of the palet but join the axillary bundle independently. Lobes and stipular structures of the border of the palet, which sometimes occur, need never be confused with lodicules.

4. The posterior lodicules of the Stipaceæ investigated, and probably in all grasses where they are present, are really later to appear

than the anterior and are also probably inserted somewhat higher on the axis. Consequently the lodicules, when all are present, continue the distichous arrangement of the palet and glume."

In accordance with these conclusions, Hackel formulated his interpretation of the organs of the flower in grasses. It may be noted that Hackel expresses doubt about his interpretation of the significance of the posterior lodicule.

Usually the bamboos have the posterior lodicule present and, in a few species, there normally develop two trimerous whorls of lodicules. Last summer a bamboo (*Arundinaria falcata*) produced flowers in the University garden and the writer took the opportunity to study the flowers in detail with special reference to Hackel's conclusions.

Warming in his *Systematic Botany* (p. 291) regards the Bambuseæ as the most primitive of the tribes of the Gramineæ, and it seems to me that a fair consideration of their floral structure and their geographical distribution bears out his opinion. He also states the theory of the grass flower substantially as the writer is about to present it, but he gives this theory in brackets after having in the preceding paragraph given the bract theory in italics. If the bamboos be the most primitive of the grasses, then surely the lodicule in this group of plants ought to shed light on the question of their morphological significance.

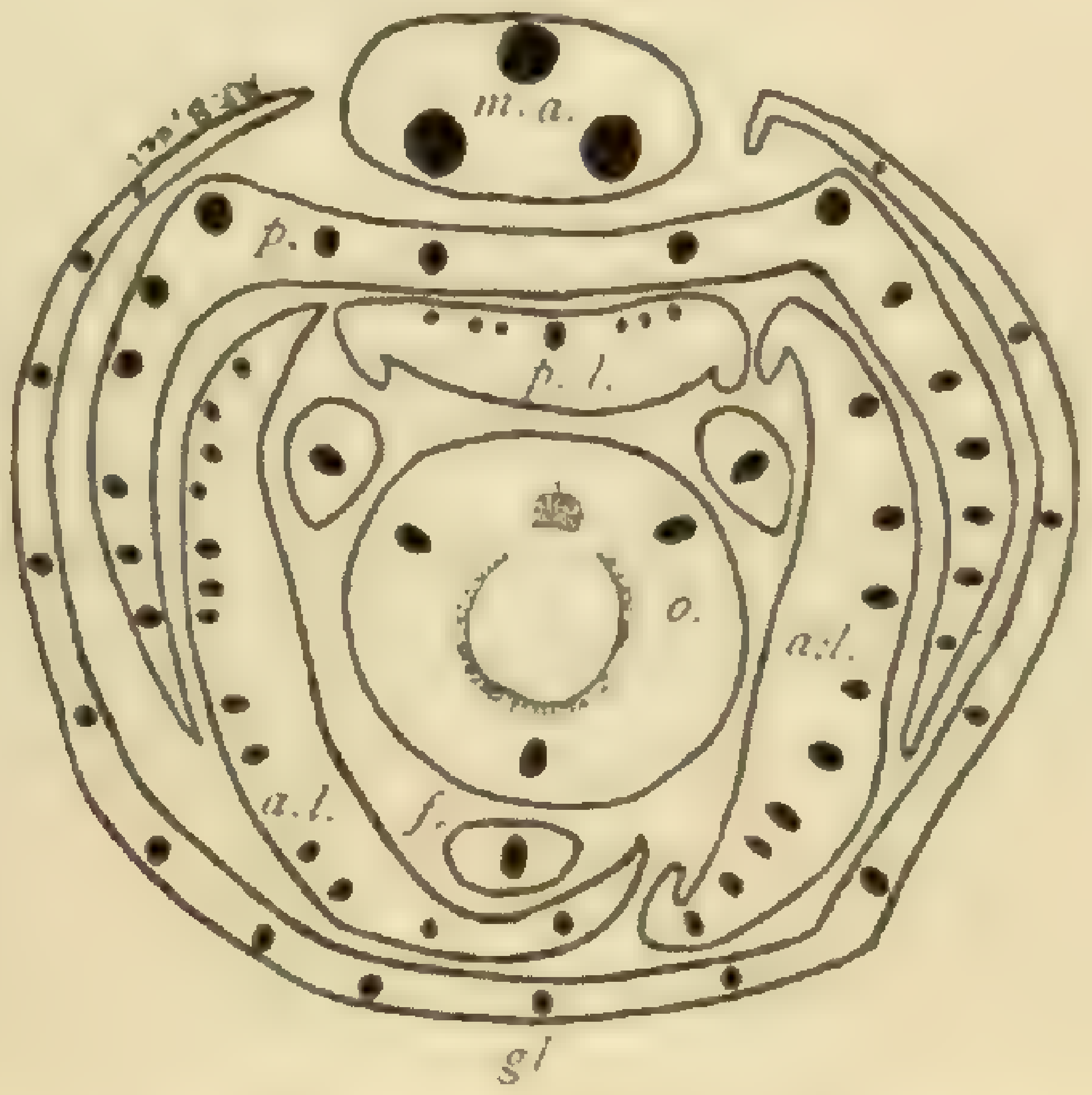

FIG. 1.—Cross section of flower of Arundinaria with subtending glume and palet: *m. a.* main axis; *gl.* flowering glume; *p.* palet; *a. l.* anterior lodicules; *p. l.* posterior lodicule; *f.* filament; *o.* pistil.

Serial cross and longitudinal sections of the flower were made and figs. *1* and *2* are representations of what was found.

There occur in the ovary walls the three midribs of the coherent carpels. That these are midribs is the more certain since the suture upon which the single ovule is borne is midway between two of them. The ovule is borne upon the posterior side of the ovary. The stamens in this species stand directly opposite the midribs of the carpels. The inner whorl, present in some species of bamboos, is suppressed here. The lodicules alternate with the stamens and may be considered therefore the inner whorl of the perianth. The lodicules are all alike in form and in structure. The anterior ones do not give the impression of being "the lateral halves of a leaf." Their inturned margins, symmetrically distributed bundles, narrowed base, and trimerous arrangement with the posterior lodicule, make it very certain that they are foliar units, the equivalents of petals. As to the height of insertion of the posterior lodicule, there can be no doubt but what, in our plant, it is inserted higher on the axis than the anterior ones. This condition might reasonably be expected where organs are crowded together so closely as on the posterior side of this flower. That the place of inser-

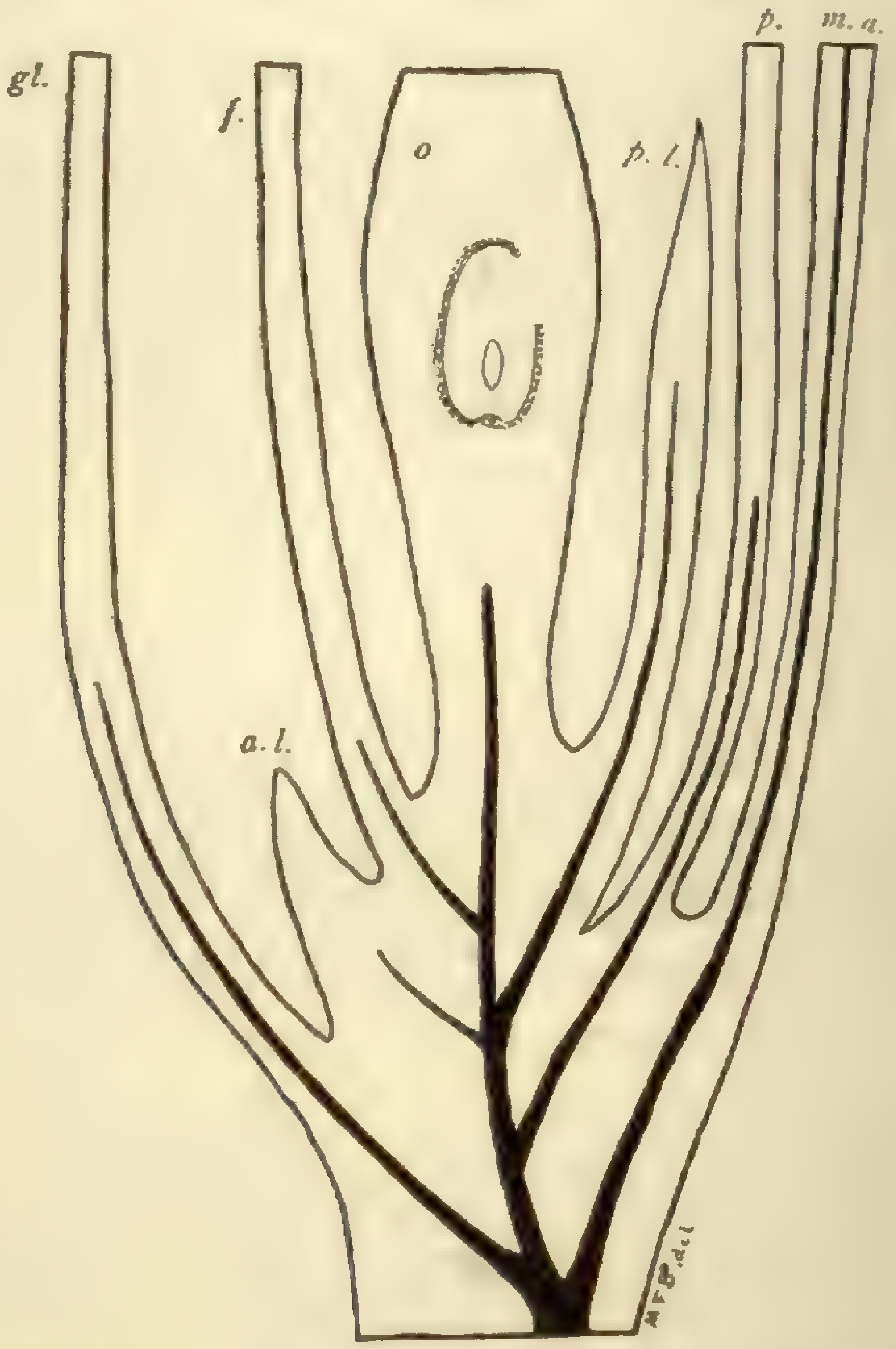

FIG. 2.—Longitudinal section of flower of Arundinaria, with particular reference to the insertion of the vascular bundles of the lodicules. Lettering same as in *fig. 1*

tion is of little importance in this regard is shown by the fact that the palet also is inserted above the anterior lodicules. Tracing down the vascular strands of the three lodicules, they are found to unite with the central strand of the axis at approximately the same point, while the vascular strands of the palet unite with the axial strand below the insertion of the strands of the lodicules. The insertion is disguised by the adhesion of the palet to the posterior lodicules.

Hackel in his discussion neglected the general law which governs the arrangement of leaves on a branch among the grasses. As is well known, the leaves on a branch are inserted in a plane at right angles to the plane in which the leaves on the main axis are borne. Hackel's conclusions reverse this law and maintain that the leaves (lodicules) on the floral branch are in the same plane as the leaves (glume and palet) on the primary axis. Such a departure from normal arrangement is scarcely probable.

It seems to me that Hackel attaches too much importance to the fact that the lodicules appear as a single rudiment afterwards becoming two-lobed. The rudiment (Anlage) of the corolla in a great many plants arises as a continuous collar of the receptacle, and afterwards the lobes are differentiated.

The question is one of considerable moment. Taking one view there is more reason for believing the grasses a group connected by intermediate forms to other monocotyledons; taking the other, the grasses must stand as a more isolated group, and the recent assumption that they are but very remotely connected genetically with other monocotyledons would have more to support it. The question also bears on the primitive character of the bamboos. — W. W. Rowlee, *Cornell University.*

OPEN LETTERS.

A REPLY.

AT the close of a review of one of my papers in the GAZETTE, January 1898, p. 67, there is a statement which reflects on me in such a way that silence would virtually imply admission of the charges. I am therefore obliged, albeit reluctantly, to make answer. This statement is as follows: "There is a curious omission of reference to the researches of Dr. H. L. Russell on this disease, some of which have already been published, as well as those unpublished, of which Dr. Smith was fully cognizant. We reserve further comment on this matter until the publication of Dr. Russell's paper, of which advance sheets have reached us." In general it is wisdom to hear both sides of an argument and to know something about the merits of a case before pronouncing judgment. I am satisfied that had the reviewer taken this ordinary precaution the above criticism would never have been written, and certainly never printed. Under the circumstances, I must beg to make an explanation.

My own studies of the parasite which causes the black or brown rot of turnips, cabbages, and allied plants, began in the fall of 1896, and have been continued uninterruptedly to date. During this time I have alluded to the subject or spoken at length upon it in seven public addresses, viz., before the Massachusetts Horticultural Society in Boston, March 1897; before the Washington Botanical Seminar early in 1897; before the Washington Biological Society, May 1897; before Section G. of the A. A. A. S. at Detroit, August 1897; before the Rochester Academy of Sciences, October 1897; before the Society for Plant Morphology and Physiology at Ithaca, December 1897; and, finally, before the Peninsula Horticultural Society at Snow Hill, Md., January 1898. Notices of a number of these addresses went into newspapers and journals. During the same time I have published three articles on this organism: first, an abstract of the address before the Biological Society of Washington;[1] second, a long paper in the *Centralblatt für Bakteriologie*, published in three parts, July 7, August 18, September 10, 1897;[2] and finally, from the U. S. Department of Agriculture, a Farmers Bulletin,[3] describing the results of field studies and showing how the disease may be prevented. For the information set forth in these lectures and papers I am in no way indebted to Dr. Russell.

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[1] Science, **5** : 963. June 18, 1897.

[2] 3^2 : 284, 408, 478. *pl. 1.*

[3] No. 68, January 8, 1898.

The paper reviewed in the GAZETTE was sent to the *Centralblatt* early in the spring of 1897. Proof on the whole of it was read and returned May 4. Some reprints of the paper were distributed in this country September 29 and the rest October 23. Up to the date of this writing (January 28) Dr. Russell has, on the contrary, so far as I know, not published any important information respecting this parasite *Pseudomonas campestris* (Pammel), in fact, he did not seem to know of Professor Pammel's paper until I called his attention to it. Whatever "advance sheets" the reviewer may have seen, I have not seen any, neither has the general public, nor do I know what their contents may be. The expression, "some of which have already been published," probably alludes to a paper by Dr. Russell, which was read at the Springfield meeting of the A. A. A. S. in August 1895. I was not present at that meeting and never learned orally or through writing as to the contents of this paper. I desired very much to read the paper, but it was withheld from publication, and the only abstract of any value which I have been able to find is in the Proceedings of A. A. A. S. **44** : 193. 1895. I might have alluded to this short abstract and would have felt compelled to do so had I been considering cabbage diseases in general, rather than writing a paper on a particular organism. This abstract I read carefully a number of times, but never found anything in it which in any way aided me in my investigations. The symptoms of the disease are not carefully described, it had not been produced by inoculations with pure cultures, and the author was evidently in error as to the common natural methods of infection as the following citation shows: "The disease is first noticeable in the axil of the lower leaves in the sulcus on the upper side of the petiole. This depression is usually filled with moisture and the disease often gains entrance at this point through the mechanical rents that are caused by the rapid growth of this succulent tissue." On the contrary, the disease due to the organism which I have studied is generally first noticeable at the margins of the leaves. He also stated that his rot "spreads rapidly in the loose cellular parenchyma" of the petioles, which is not true of *Pseudomonas campestris*. Finally, there is not a line as to what kind of an organism he was experimenting with. Subsequently Dr. Russell told me (November 1896) that he was at that time (1895) working with the "wrong germ," namely, with a white organism, and this probably explains why he withheld the paper from publication, and also explains why I preferred to pass over the abstract in silence.

Now, as to what I have learned orally or by correspondence with Dr. Russell, or from other people, concerning his "unpublished" work, so as to be "fully cognizant" of it. The whole thing can be put in a nutshell. How I first came to undertake the study of this organism is sufficiently set forth in the first part of the paper reviewed. Not until my investigation was well under way and I had asked for and had received a second shipment of cabbages from Racine did I know that samples had also been sent to Dr. Russell, and that he had again undertaken to find out the cause of the disease. At no time have I visited his laboratory or seen any of his cultures or any of his experiments, or had any desire to know what he was doing. In November 1896, Dr. Russell visited my laboratory desiring, as he said, "to talk shop," or, in other words, to learn what I was doing. Some of his questions I answered, others I parried, as any other man would have done, not desiring to give away to another working in the same lines information relating to an unfinished piece of research. At that time he said he had secured no infections and was unable to get the organism to grow in beef broth. He obtained from me a few facts which probably were of use to him, namely, that I was still working on the disease, that my organism was yellow, and that it would grow in properly made beef broth. From him I received the statement that the organism which he was then studying was yellow, the other statements which I have given above, and the fact that the loss at Racine exceeded $75,000. I obtained from him no facts which in any way changed my plan of work, and no ideas which were of any value to me except the statement as to the approximate pecuniary loss at Racine, which statement I carefully refrained from using, depending rather on general statements furnished by cabbage growers. If Dr. Russell had any ideas at the time as to the mode of infection or other interesting peculiarities of the organism, they were not revealed to me.

This is all I knew definitely of Dr. Russell's work until ten months later (September 1897) after the publication of two-thirds of my paper and within a week of the appearance of the remaining part. He then informed me that he had also secured infections and was preparing a paper for publication. He volunteered, however, scarcely any information concerning the details of his work, and no information whatever of which I have made any use, neither did I ask for any, nor desire any.

Such are the sole grounds for the charge of omission to give credit for work already done, and of being "fully cognizant" of unpublished work. Dr. Russell, as I learned from a conversation with him in September 1897, seems to have gone away from Washington with the idea that I would drop work on the germ, but I did not designedly or intentionally give him any such impression.

It has always been my desire to give all work the fullest recognition. If any one has cause to accuse me of sins of omission, it is not Dr. Russell but Professor Garman, who published a paper three years before the reading of Dr. Russell's Springfield paper (*Agricultural Science*, July 1892, pp. 309-[illegible]) on a bacterial disease of cabbage, and which, if it did not go very far, is at least cautious, covers much the same ground as Dr. Russell's abstract, and is a much more useful contribution to science. I omitted mention of this paper because no infections were obtained from pure cultures, because the two organisms which were isolated were not described so as to be identifiable, and finally, because I was describing a specific germ and not writing a general treatise on cabbage diseases of which there appear to be several due to bacteria. The one man who has written on this organism so that other bacteriologists can make something out of his writings is Professor L. H. Pammel, to whom I gave full credit. Since the paper in question was written I have removed the final shadow of doubt respecting the identity of the organism which Professor Pammel described and the one I have studied, by the discovery that whether it *does* or *does not* liquify gelatin is an accident depending entirely on how the gelatin is made.— ERWIN F. SMITH, *Washington, D. C.*

[WE PUBLISH the above at Dr. Smith's request. Dr Smith could hardly have written it had he awaited the promised comments when Dr. Russell's paper was noticed (see p. 211). The reviewer was cognizant of the facts which Dr. Smith relates above (and some others) when the statement he quotes was written, and sees no occasion to change his judgment. It was as far from his thoughts then as now to charge Dr. Smith with improper use of information; nor can such an implication be found in the review. Dr. Smith is certainly entitled to the full credit of independent work. The complaint was rather that it was *too* independent (witness the allegation, "at no time have I . . . . had any desire to know what he [Russell] was doing"); and we can see no explanation of the studious avoidance of any reference to the antecedent and contemporary work of Dr. Russell, of which, by his own statement, he *was* "fully cognizant." We leave readers to judge of the validity of the reasons assigned for passing over it in silence. We only remark that, under the circumstances, Dr. Smith had every reason to know that the disease described by Russell, even though imperfectly, was identical with the one he was working upon. Nor does he improve his relation to the matter by magnifying now the errors of that preliminary notice. In newspaper parlance the earlier publication of important information constitutes a "scoop," and in newspaper rivalry, to "scoop" a competitor is not only legitimate, but praiseworthy. It is hardly so regarded in scientific work.— EDS.]

BOTANY AT BROWN UNIVERSITY.

To the Editors of the Botanical Gazette:— I think it is my privilege to correct a wrong impression likely to be conveyed by the recent notice of my *Notebook* in the GAZETTE. Personally I am wholly indifferent to the criticism, but as my university is involved in the charge of erroneous teaching, I feel bound to say a word in her defense.

It is said in the review that a glimpse is here given of the mode of teaching botany at Brown. A glimpse, yes; a comprehensive view, no. My *Notebook* is designed wholly for primary students and has been found to meet its purpose admirably well. Histology and the lower cryptogams, involving use of compound microscopes and reagents, are thoroughly studied by select students.

As to the point at which a course of botany should begin, opinions differ and we acknowledge no infallible head to decide the question. East of the Hudson, at least, there are many who agree with us, that while theoretically it is right to begin with the cell, it is impracticable with large undergraduate classes pursuing the course only three hours a week. As to the interest, it is certainly debatable whether the study of morphology is not quite as interesting, and for academic courses as inspiring, as the development of the *punctum vegetationis*. As a matter of fact, so-called "analysis" occupies but a few weeks of our course.— WM. WHITMAN BAILEY, *Brown University*.

[WE ARE sorry that Professor Bailey thinks that "histology" and the "punctum vegetationis" are the only recourse for those who would not begin botany with the "analysis" of spermatophytes. We do not consider it debatable at all as to whether morphology or histology is the more "inspiring" to the beginning student. We agree entirely with Professor Bailey's position in this matter. We only thought that a little less intricate terminology would give more time for morphology, and allow some of the lower forms to come in.—EDS.]

CURRENT LITERATURE.

BOOK REVIEWS.

Nature study.

THE infusion of nature study into our conventional education is like breathing life into a dead body, and yet no subject is in a more chaotic state. It is in danger of being condemned before it has had a fair chance to justify itself. Thrust into the hands of untrained teachers, it has brought to them and their pupils bewilderment and disgust. To give them help, unscientific bookmakers have attempted to organize the subject, and the result has usually been a jumble of ignorance and sentiment. The problem is peculiarly difficult, for it must bring to its solution both experience in teaching children and knowledge of science. Those who have the former qualification have been alone in trying to solve the problem, and have thus far made a conspicuous failure. Those who have only some knowledge of science would be very apt to make an equally conspicuous failure. At least they seem to know enough not to attempt it. Not only is scientific knowledge demanded, but a first-hand knowledge of almost all sciences, and this would naturally cause all but the unscientific to shrink from the task. A book[1] has just appeared which announces the principles of nature study, so far as plants are concerned, with the truest insight. Nothing could be better than the following statements: "Function should precede form;" "It is not important at all to know that the root is fibrous, nor even that the ovate leaves are palmately veined, with a sinuate tooth margin, and are alternately arranged on the stem;" "As a general rule systematic observation defeats its object and stultifies the perceptions of the children; therefore, the main thing should be to keep the *life* side before them."

This certainly rings true, but unfortunately, these excellent ideas do not become embodied in the exercises suggested. Not only are schools afflicted with a conventional education which nature study seeks to vitalize, but there is also a conventional form of botanical instruction which by no means "keeps the life side" before the pupil. Our author knows what she wants, but has not been able to escape the conventional botany. There are a few exercises with leaves which serve to hint at their life relations, and this is about all. Even the exercises in seed germination, as usual, call atte to the non-essentials and miss the large facts. As for the bulk of the it is the usual round of taking up plant after plant and observing its stru side, not its "life side." There is some interesting non-scientific infor about plants, but this seems to be in order to arouse a factitious inter an otherwise dull task. Even at the beginning of the second year, the tion is to "teach the names of the floral parts — calyx (sepals), (petals), stamens, pistil — and their uses."

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[1] WILSON, MRS. L. L.—Nature study in elementary schools. Small 8vo. pp. [illegible] + 262. The Macmillan Company: New York. 1898. 90 cents.

We are told that "in the paragraphs marked 'Facts' such nec knowledge on the subjects therein treated" is given as the teacher is expe to possess; and also "these facts are accurate and based upon the late most eminent authority," an expression which makes one shudder nature study is designed to banish the book and to break the shack "authority." In looking over these "facts" it becomes evident that many of them have been taken from "eminent authority" rather than observation.

The statement that "the course here presented does not presu special training on the part of the teacher" presents a heresy which ca be too vigorously denounced. It is further stated that "it is not my inte to disparage the value to the teacher of special training in science. N theless, it may be safely stated that the courses generally pursued in c and university do not necessarily equip the student for practical eve work with little children. They need to be supplemented by actual e ence," chief of which, we venture to say, is experience with the s Wooden teaching by those who are not trained in a subject is nowhe conspicuously a failure as in nature study, where the greatest flexibility the use of material is absolutely necessary.

The book before us is fuller of good intention than any guide to n study that we have seen; but it will take a good deal of training in the side" of plants to enable one to carry out the intention.— J. M. C.

MINOR NOTICES.

Mr. James M. Macoun has published another one of his "Contri to Canadian Botany."[2] It reports plants new to Canada, new stati changes in nomenclature.— J. M. C.

Mr. Edwin B. Uline has published the first part of a monograph of Dioscoreaceæ[3] as his doctor's thesis at the University of Berlin. The is devoted to morphology, especially in its relation to the classification group, and necessarily involves considerable compilation, accompanie discussion of the systematic value of organs. A constancy in the direction of stem twisting, whose importance in classification has been worked out by the author, proves invaluable as a group character, while the importance of characters derived from tuber, rootstock, etc., seem to have been much overestimated heretofore. *Testudinaria* Salisb. has been reduced to a subgenus of Dioscorea, this south African genus having been based upon its tessellated aerial rootstock. The same rootstock was found on the Mexican *Dioscorea macrostachya*.

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[2] Reprint from Canadian Record of Science 267–286. 1897.

[3] Eine Monographie der Dioscoreaceen, Leipzig, Wilhelm Engelmann. Dec

The following classification is made of the "edible" tubers of the family:

1. Root structure: character uniform.

2. Stem structure: *a*. growth directed downward, subterranean; *b*. growth directed laterally, subterranean; *c*. growth directed upward, above ground.

The striking external differences in *a*, *b*, and *c* are the outcome of variation in the relative position of the most active cambium, and this activity expresses itself quite independently of genetic relationship.

Grisebach and Kunth based their system for the family chiefly upon the character of the staminate flowers, having had but few pistillate plants to examine. The result was that staminate and pistillate plants belonging together were usually described as separate species, and *vice versa*. This arrangement has been very largely abandoned by Dr. Uline, whose exhaustive study of larger and later collections has enabled him to clear away many of the difficulties.

An undescribed kind of hydathode has been found on the leaves of certain African species, and is briefly described.

The chapter "Das System" is but a forecast of the unpublished systematic part, while that on "Geographie" is of unusual value on account of the new perspective, and on account of the exceptionally thorough representation afforded by the material studied.—J. M. C.

A BULLETIN by Dr. H. L. Russell of the Agricultural Experiment Station of the University of Wisconsin, entitled "A bacterial rot of cabbage and allied plants," has recently come from the press.[4] In it is given an account of the origin, symptoms, mode of transmission, and geographical distribution of a bacterial disease which for a number of years has been doing great damage to cabbage and allied plants in various parts of the United States. The morphological, physiological, and culture characters of the organism producing it have been carefully worked out by Mr. H. A. Harding, who has been assisting Dr. Russell.

This is the same disease upon which Dr. E. F. Smith last year published a paper, noticed in this volume, p. 67, and upon which later he issued a Farmer's Bulletin (no. 68) of the U. S. Department of Agriculture. The two investigators agree in almost every particular regarding the disease, so that the main facts may be considered as thoroughly established, having been worked out independently by two competent observers.

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[4] No. 65. February 1898. pp. 39. figs. 15.

It is rather unfortunate, however, that time should be spent in duplicating work, when there is so much to be done. In this particular case, certainly courtesy, not to say economy, demanded that investigation of the disease should not be assumed by the national department, but rather that the work should be left in the hands of the state experiment station, which had a thoroughly trained observer already engaged upon it. In 1895 Dr. Russell presented to the Springfield meeting of the A. A. A. S. a brief preliminary note on "A leaf rot of cabbage," for the purpose of eliciting information in regard to the disease. In this he alludes to certain striking symptoms which serve to identify the disease. His studies were continued in 1896, in the autumn of which year Dr. Smith began his investigation. Scarcely had he begun when he knew Dr. Russell was not only continuing his studies, but had been appealed to by the cabbage growers of Racine, Wis., to find out the cause of their serious losses. The material on which Dr. Smith's first studies were based was sent to him from that locality. While there is no civil law which compels the U. S. Department of Agriculture to keep out of, or withdraw even from work previously undertaken by a state experiment station, there is a law of courtesy which demands it, and Dr. Smith would have done well to heed it.—C. R. B.

NOTES FOR STUDENTS.

ITEMS OF TAXONOMIC INTEREST are as follows: Marshall A. Howe[5] has published a revision of the Anthocerotaceæ of North America, containing ten species of Anthoceros (three of which are new), and two species of Notothylas. Six handsome plates accompany the paper. Anna M. Vail[6] has published a revision of the genus Acerates in the United States, recognizing seven species, one of which is new. John K. Small[7] has published twenty-two new species of Eriogonum, and has constructed a new genus (*Acanthoscyphus*) upon the Californian *Oxytheca Parishii* Parry. H. Eggers[8] has published a new genus of Artocarpeæ from Ecuador, naming it *Poulsenia*.—J. M. C.

THE RECENT DISCOVERY of spermatozoids in Cycas and Zamia has given renewed interest to the study of the Cycadaceæ. Dr. D. H. Scott[9] has discovered in the peduncles of Stangeria and some other cycads the same peculiar (mesarch) type of vascular bundle as has long been known to occur in cycad leaves. Mesarch bundles are found in certain fossils of cycadean stock (Bennettiteæ, Medulloseæ), in the leaves of Cordaiteæ, which like recent cycads had normal stem bundles, and in Lyginodendron and Poroxylon. Dr. Scott's discovery establishes a new link between the Cycadaceæ and the Lyginodendreæ and, coupled with the occurrence of mesarch bundles in these palæozoic plants, makes it probable that this kind of bundle formerly occurred in the stems as well as leaves of cycads. He thinks the loss has been due to the early and increasing development of secondary tissues from the cambium.

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[5] Bull. Torr. Bot. Club 25: 1–24. 1898.

[6] Bull. Torr. Bot. Club 25: 30–39. 1898.

[7] Bull. Torr. Bot. Club 25: 40–53. 1898.

[8] Bot. Centralbl. 73: 49. 1898.

[9] The anatomical characters presented by the peduncle of Cycadaceæ. Annals Bot. 11: 399–420. 1897.

Mr. W. H. Lang[10] has investigated the microsporangia of *Stangeria paradoxa*. The nearly mature sporangium has a wall five or six cell-layers in thickness, and the spore mother cells are immediately invested by three differentiated layers. The inner layer is the tapetum, which is not distinguishable till the sporangium is well grown, and then arises from the sporogenous mass. The other two specialized layers are derived from the sporangium wall and consist of flattened cells. The archesporium was not traceable to a single cell, but was a plate of four cells derived by a periclinal division of four large hypodermal cells.—W. R. SMITH.

THE RADICAL DIFFERENCE of opinion regarding bacterial structure which at present exists among investigators who, like Bütschli and Fischer, are most conversant with the subject-matter, naturally makes all interpretations of the observed facts appear more or less in the light of *obiter dicta*, and one of the latest contributions[11] to this interesting discussion can hardly escape being placed in the same category with the others. Meyer, nevertheless, brings to the problem a far richer contribution of fact than is contained in some of the recent polemical deliverances.

A large bacterium (regarded by Meyer as a new species, and named *Astasia asterospora*), which was found upon boiled carrot, afforded especially favorable material for investigation, and the author claims that the use of very high magnifications, combined with carefully chosen illumination, greatly facilitated his study. The spore of Astasia germinates under certain conditions in about six hours, and gives birth to a motile rod which divides and subdivides into new motile forms. After about twelve hours some of these motile individuals come to rest, secrete a gelatinous envelope, and become quiescent, although continuing to divide. Some, but not all, of these rods in the quiescent stage become sporangia, as Meyer terms them, and each sporangium forms one true endospore. The cylindrical spores present somewhat complicated structure: a two-layered membrane exists, the yellowish outer layer (exine) being raised into ten ridges which traverse the long. axis. Viewed from the end the spore is star-shaped. The motile rods that come from the spores possess tufts of flagella, the small cells having but one tuft and the larger never more than from two to four. The individual flagella composing the tufts are exceedingly fine and delicate. These bunches of cilia are never found at the pole, but are always on the side of the cell, and are usually disposed asymmetrically. Meyer would found a new subfamily and genus (Astasia) upon this curious one-sided arrangement of ciliary tufts.

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[10] Studies in the development and morphology of cycadean sporangia. Annals Bot. 11: 421–438. 1897.

[11] ARTHUR MEYER. Studien über die Morphologie und Entwickelungsgeschichte der Bacterien, ausgeführt an *Astasia asterospora* A. M. und *B. tumescens* Zopf. Flora 84: 185–248. 1897.

In nearly all stages of development, structures which Meyer regards as nuclei may be revealed by certain methods of staining. A staining solution that gave particular satisfaction was employed after fixation with osmic acid vapor, and was prepared as follows: 0.02^{gr} ruthenium red, 6^{cc} water, 2^{cc} 95 per cent. alcohol. The coloration obtained with this solution is permanent in glycerin and glycerin-gelatin, but does not hold in Canada balsam. With this method each cell shows one to two and rarely three to four deeply stained granular structures. Other nuclear stains were used with similar results, and Meyer looks upon the granules reacting to these stains as true nuclear substances. He rejects the view that bacteria are undifferentiated "protoplasts" or "archiplasts," as well as Bütschli's conception that the bacterial cell is chiefly nuclear substance surrounded by a mere fringe of cytoplasm.

A study of *B. tumescens* convinced Meyer that the process of spore formation occurs in this species in the same fashion as in Astasia and not in accordance with the statements of earlier workers. He is inclined to extend his observations upon these two species to a generalization covering the whole group of bacteria, and to believe that this method of spore-formation indicates close relationship of the bacteria to the Ascomycetes.—E. O. JORDAN.

MR. W. L. BRAY has recently published a short paper on the geographical distribution of the Frankeniaceæ, considered in connection with their systematic relationships.[12] This paper follows along the line of Engler's studies on the Rutaceæ,[13] and aims to correlate the facts of taxonomy with those of ecology and plant geography. The Frankenias are a small family of plants of extreme halo-xerophytic character and are found in nearly all salt steppes scattered all over the globe, and are always halophytic; hence they are peculiarly well adapted for a study in ecological phylogeny. The various species are taken up in detail by geographic regions, viz., the Mediterranean region, South Africa, Australia, South America, western North America and several oceanic islands. Australia, South America and the Mediterranean districts

[12] Eng. Bot. Jahrb. **24**: 395–417. 1897.

[13] See BOT. GAZ. **23**: 220. 1897.

are the three large centers of development. The author divides the family into two groups, one of which includes nearly related forms occurring in most salt steppes, and the other including a large number of monotypic forms in isolated locations, and sharply distinct from each other, the remnants of a previous development. The character of the first group requires the supposition of migration within rather recent times, and the original center was probably Australia or the Mediterranean region, the American forms having come from Australia. A southern extratropical origin seems most likely. The means of dispersal is not clear, since the seeds are not adapted for flotation nor for clinging to objects, such as birds. The character of the second group leads Mr. Bray to the idea that the isolated forms are relics of a far wider distribution in the past, when there were, perhaps, much more extensive halophytic areas than exist today.—H. C. COWLES.

CONTINUING THE WORK of Kny, Mr. C. O. Townsend[14] has completed a series of experiments at Leipzig in the Pfeffer laboratory, whose results throw new light upon the precise effect of injury upon growth. The study was limited to seed plants, excepting a number of experiments upon *Phycomyces nitens*. Cuttings and introduction into an atmosphere of ether were the injuries employed. The fully tabulated results definitely establish that slight injury to root or shoot promptly accelerates the rate of growth, while, as the severity of the injury is increased, the acceleration becomes preceded by a varying period of retardation. In seed plants the minimum "latent period" observed was six hours, but in Phycomyces injury to the mycelium produced almost immediate retardation of the growth of the sporangia stalks, the normal rate being restored in from thirty to sixty minutes. Such irritation was found to act through distances up to 260 ^{mm}, slight injuries to the root tips becoming soon apparent in changing the rate in the growing zone of the stem. The change may vary from the normal rate by 0 to 70 per cent., but only the most general results could be foretold from a specified injury; largely, of course, because the influence of turgor could not be eliminated.—J. G. COULTER.

A. PREDA[15] has recently investigated the embryo sac of several Narcissus forms, some of which were hybrids. In the hybrids various degrees of reduction were noted. Sometimes there was a small sac with egg apparatus and endosperm nucleus, often there was no trace of a sac, and in some cases not even the ovules were developed.

In referring to chromatophily the author quotes Auerbach, who would make the terms cyanophilous and erythrophilous almost synonymous with male and female ; Strasburger, who makes the erythrophilous or cyanophilous condition depend upon abundant and impoverished nutrition respectively; and Zacharias, who says that the reaction depends upon the amount of phosphorus present in the nucleus, the nuclei rich in phosphorus being cyanophilous. He says that Zacharias' theory does not agree with Strasburger's, and also quotes Rosen's researches upon meristem as contradicting the nutrition theory. The author claims that the reactions in Narcissus are also at variance with Strasburger's views. It seems to us that the usual embryo sacs at least afford no contradiction to Strasburger's theory, and from the description Narcissus does not appear to be any exception to the rule. The fusion of polar nuclei is regarded as an act of fertilization and the endosperm as a new plant.

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[14] The correlation of growth under the influence of injuries. Annals of Botany 11: 509–532. 1897.

[15] Recherches sur le sac embryonnaire de quelque Narcissées. Bulletin L'Herb. Boiss. 5: 948–952. 1897.

The author killed his material in alcohol, and though he imbedded it in paraffin, he preferred the ordinary razor to the microtome.—C. J. CHAMBERLAIN.

WÄCHTER has been carrying on experimental studies on water plants with a view to making clearer our knowledge of the relations existing between leaf form and external conditions.[16] Goebel's work on similar problems suggested the nature of the experimentation, and the author's results confirm Goebel's previous conclusions quite fully.[17] The first part of the paper treats of the influence of external agents on various monocotyls, especially Sagittaria. It is well known that leaves developed in deep water are narrow, while those developed in shallow water are much broader and often sagittate in some species. Goebel showed that this, like other leaf forms, is a light relation. Wächter conducted all sorts of experiments, producing both types of leaves at will. Plants grown on the land developed broad leaves, while broad-leaved land forms developed narrow leaves when placed in water. Narrow leaves were produced in land forms that were insufficiently nourished, and also where grown in weak light. The author concludes that leaf form is not predetermined, but depends on environment, being fundamentally a matter of nutrition. The second part of the paper is a morphological and anatomical study of Weddelinia, and the third part describes the results of experimental work on Nymphæa, which are quite similar in general character to those described above for monocotyls.—H. C. COWLES.

IT HAS RECENTLY been shown by Professors Babcock and Russell[18] of the University of Wisconsin that the ripening of cheese is partly due, at least, to the presence of proteolytic enzyms, normally contained in milk, whose existence has not before been recognized. Heretofore the changes during the ripening process have been wholly ascribed to the action of bacteria.—J. C. A.

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[16] Flora 83 : 367–397 ; 84 : 343–348. 1897.

[17] See Bot. Zeit. 38 : 752. 1880 ; Flora 72 : 1. 1889 ; Biologische Schilderungen.

[18] Flora 80 : 96–116. 1895 ; 82 : 1–13. 1896.

[19] Centr. f. Bakt. u. Paras. 3^2 : 615–620. 1897.

NEWS.

Miss Julia Snow, Ph.D. (Zürich) has been appointed Instructor in Botany in the University of Michigan.

Mr. John Donnell Smith sailed for Europe about the middle of March, expecting to be absent until the middle of October. He will divide his time between Spain and England.

James Bateman, whose monumental work on the orchids of Mexico and Guatemala is one of the sights of the great libraries, died November 27, 1897, at his home in Springbank, near London, at the age of 86.

The new *Journal of Applied Microscopy* has begun a series of articles on "Representative American laboratories." The first ones to be described are those of Cornell University, in the February number of the journal.

Sir Joseph Hooker's great work on the Flora of British India has at last been completed, a work which has been in mind and in hand more or less since 1848, when the author made a botanical investigation of the Himalayas.

Dr. John M. Coulter, of the University of Chicago, and Dr. Douglas H. Campbell, of Leland Stanford University, have recently been elected associate fellows in the section of botany of the American Academy of Arts and Sciences, Boston.

With the beginning of the year the *Bulletin of the Torrey Botanical Club* passed under an entirely new editorial management. The organization is as follows: *Editor*, Lucien Marcus Underwood; *Associate editors*, Carlton Clarence Curtis, Byron David Halsted, Arthur Hollick, Marshall Avery Howe, Francis Ernest Lloyd, and Anna Murray Vail.

The price lists of native ornamental plants from the nurseries of Edward Gillett, of Southwick, Mass., and F. H. Horsford, of Charlotte, Vt., have recently come to hand. These dealers, as well as a number of others, offer a surprisingly large number of interesting plants, that are often desirable for illustrative material. If teachers knew how cheaply and easily such plants as Drosera, Dionœa, Sarracenia, etc., as well as asters, solidagos, ferns, etc., can be obtained, and how little trouble they are to grow in the garden or greenhouse, it is probable that classes would oftener have the opportunity to see the living plants.

DR. CHARLES R. BARNES has been appointed Professor of Plant Physiology in the University of Chicago. His laboratories will be equipped during the summer, and his courses will begin with the autumn quarter. The work of the Hull Botanical Laboratory has been largely morophological heretofore, and it is now proposed to put equal emphasis upon physiology, including ecology.

A STUDY of the ecological plant geography of Kansas has been made by Professor A. S. Hitchcock, and was presented before the Academy of Science of St. Louis at the meeting of February 7. The paper was referred to the council for publication. At the same meeting Professor L. H. Pammel discussed the taxonomic value of the anatomical character of seeds, a study which has engaged his attention for some years past.

THE PAPER on "Bibliographical difficulties in botany," read by Professor Edward L. Greene before the Botanical Society of America at its Toronto meeting, has been distributed as a reprint from the *Catholic University Bulletin* **4**: 62–75. 1898. The paper was very briefly summarized in BOTANICAL GAZETTE **24**: 183–185, 1897. It should be read in its complete form by all those who are engaged in determining the real names of plants.

THE EDIBLE and poisonous mushrooms are being studied in regard to their physiological action as food by a commission of the American Physiological Society, consisting of Professors Crittenden (Yale), Abel (Johns Hopkins), Pfaff (Harvard), and Bowditch (Harvard). Their first report was made to the society at its recent meeting in Ithaca, and brought out the statement that the edible fungi do not contain nearly as much digestible proteids as they are usually credited with, and that their food value in this respect has been overrated.

THE FOLLOWING PRIZES for botanical work were awarded by the Académie des Sciences of Paris, at its annual public session January 10: *Prix Desmazières* (1600 fr.) to Professor Jakob Eriksson for observations on the rust of cereals; *Prix Montagne* (1500 fr.) to Professor Bourquelot for his work on the physiology of mushrooms; *Prix Thore* (200 fr.) one-half to M. Sappin-Trouffy for investigations on the development of the Uredineæ; *Prix Gay* (2500 fr.) to Charles Flahault for his study of the geographical distribution of the French Mediterranean flora.

THE NUMBER of persons officially designated as "botanists" or "mycologists," who are at present connected with the agricultural experiment stations of the United States, is fifty, according to a recent government bulletin.[1] Fourteen of these bear in addition the title of horticulturist, entomologist, or chemist; while two have executive duties specified. The full list is as follows:

[1] Organization lists of the agricultural experiment stations and institutions with courses in agriculture in the United States. Bull. 47. Office of Exper. Sta., Wash. Gov. Printing Office, 1898, pp. 96.

State	Name	Official title
Alabama	P. H. Mell, Ph.D.	Bot.
Arizona	J. W. Toumey, B.S.	Bot., Ent., and acting Dir.
California	W. A. Setchell, Ph.D.	Bot.
"	J. B. Davy	Asst. Bot.
Colorado	C. S. Crandall, M.S.	Bot. and Hort.
Connecticut	Wm. C. Sturgis, Ph.D.	Myc.
Delaware	F. D. Chester, M.S.	Myc.
Idaho	L. F. Henderson	Bot.
Illinois	T. J. Burrill, Ph.D.	Bot. and Hort.
"	G. P. Clinton, M.S.	Bot.
Indiana	J. C. Arthur, D. Sc.	Bot.
"	William Stuart, B.S.	Asst. Bot.
Iowa	L. H. Pammel, M.S.	Bot.
"	C. R. Ball, B.S.	Asst. Bot.
"	Robt. Combs, B.S.	Asst. Bot.
Kansas	A. S. Hitchcock, M.S.	Bot.
"	Geo. L. Clothier, B.S.	Asst. Bot.
Kentucky	H. Garman	Bot. and Ent.
Louisiana	W. R. Dodson, M.A.	Bot.
Maine	F. L. Harvey, Ph.D.	Bot. and Ent.
Massachusetts	Geo. E. Stone, Ph.D.	Bot.
"	Ralph E. Smith, B.S.	Asst. Bot.
Michigan	C. F. Wheeler, B.S.	Consulting Bot.
Minnesota	Otto Lugger, Ph.D.	Bot. and Ent.
Mississippi	G. W. Herrick, B.S.	Bot. and Ent.
"	J. S. Moore, M.S.	Asst. Bot.
Missouri	C. H. Thompson, B.S.	Asst. Bot.
Montana	H. S. Jennings, Ph.D.	Bot.
Nebraska	C. E. Bessey, Ph.D.	Bot.
Nevada	F. H. Hillman, M.S.	Bot. and Ent.
New Jersey	B. D. Halsted, D.Sc.	Bot. and Hort.
New York (Cornell)	G. F. Atkinson, Ph.B.	Bot.
" "	B. M. Duggar, M.S.	Asst. Crypt. Bot.
" (Geneva)	F. C. Stewart, M.S.	Myc.
North Carolina	C. W. Hyams	Asst. Bot.
North Dakota	H. L. Bolley, M.S.	Bot.
"	Merton Field, B.S.	Asst. Bot.
Ohio	A. D. Selby, B.S.	Bot. and Chem.
Oklahoma	E. E. Bogue, M.S.	Bot. and Ent.
Oregon	Moses Craig, M.S.	Bot.
Pennsylvania	W. A. Buckhout, M.S.	Bot.
South Carolina	A. P. Anderson, Ph.D.	Bot.
South Dakota	De Alton Saunders, M. A.	Bot.
Tennessee	S. M. Bain, B.A.	Bot.
Utah	U. P. Hedrick, M.S.	Bot. & Hort.
Vermont	L. R. Jones, Ph.B.	Bot.
"	W. A. Orton, B.S.	Asst. Bot.
Virginia	W. B. Alwood	Myc., Hort., Ent. and Vice Dir.
Washington	C. V. Piper, M.S.	Bot. and Ent.
Wyoming	Aven Nelson, M.S.	Bot.

There are now fifty-one state experiment stations, one to each state on the list, except Connecticut and New York, which have two each. One of the Connecticut stations employs no botanist, and ten other state stations are also without botanists, viz.: Arkansas, Florida, Georgia, Maryland, New Hampshire, New Mexico, Rhode Island, Texas, West Virginia, and Wisconsin. It is presumable, however, that in some cases, and it may be in all, botanical work is carried on by other members of the staff, especially by the horticulturist, biologist or bacteriologist, when such officers are named. In some cases where botany is associated with horticulture or entomology, it is either largely neglected, or receives the greater share of attention, for the subjects are too large to be successfully combined, so that a few names on this list represent but nominal botanists. Yet there are recognized botanists not on the list, like Professor Rolfs of the Florida station, and Dr. Russell of the Wisconsin station, who offset such defection.

A corps of fifty trained botanists, scattered over the breadth of the land should accomplish great good both for agricultural practice and for pure science.

THE VERMONT BOTANICAL CLUB held its third annual meeting at the University of Vermont, February 4 and 5. Among the titles we note the following: Recent tendencies to recognize new species, *President Ezra Brainerd;* Dissemination of plants due to seed structure rather than number, *Miss B. C. Verder;* Among the ferns, *Rev. J. A. Bates;* Notes from field and herbarium, *Mrs. A. J. Grout, Carleton D. Howe, Dr. G. H. Perkins* and *Professor L. R. Jones;* Common notions of physiological constants, *Professor F. A. Waugh;* On collecting and preparing fleshy fungi for the herbarium, *Dr. E. A. Burt;* Vermont myxomycetes, *Miss F. M. Sutton,* and *Miss L. C. Whitney;* Vermont hepatics, *Clifton D. Howe.*

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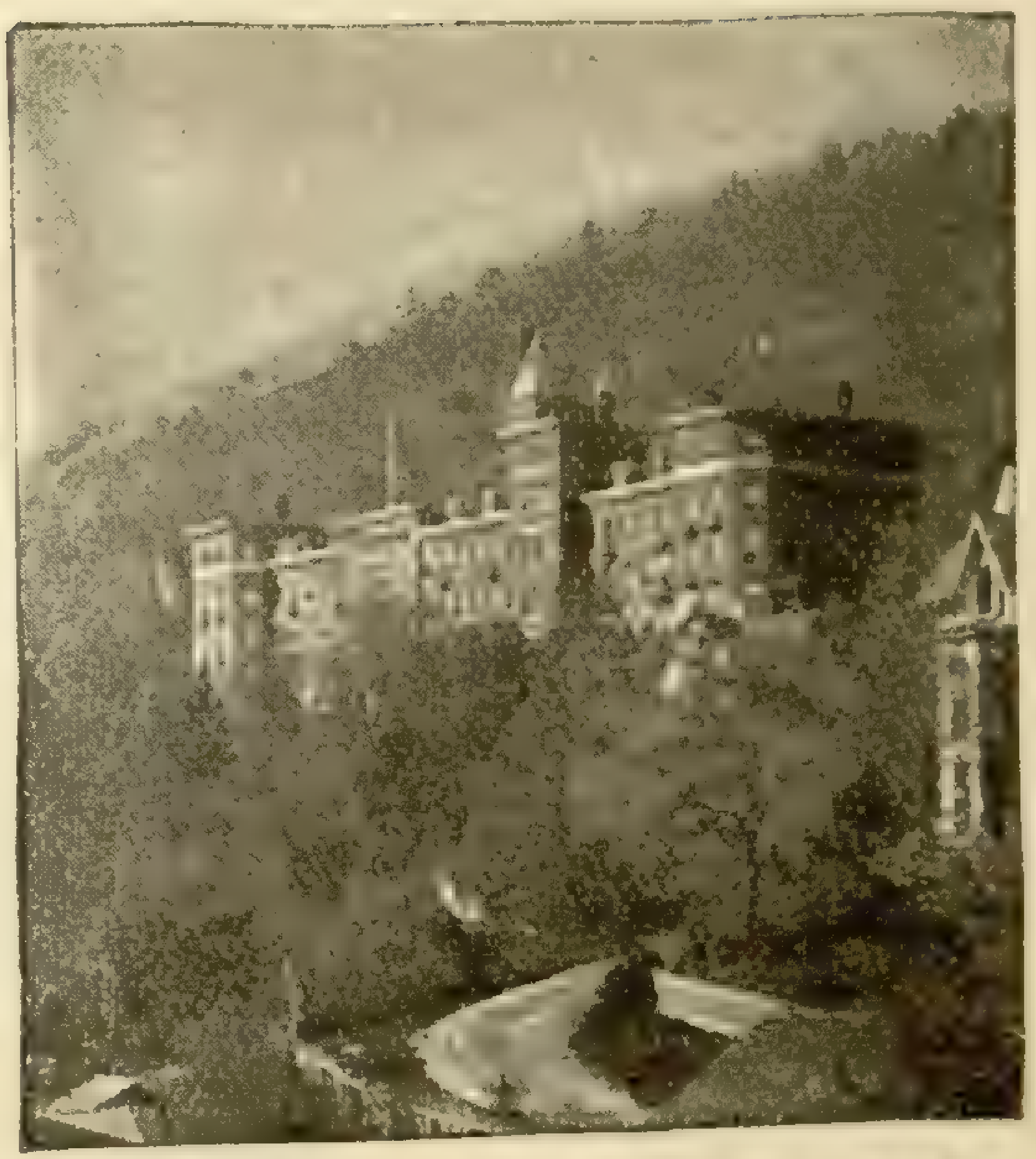

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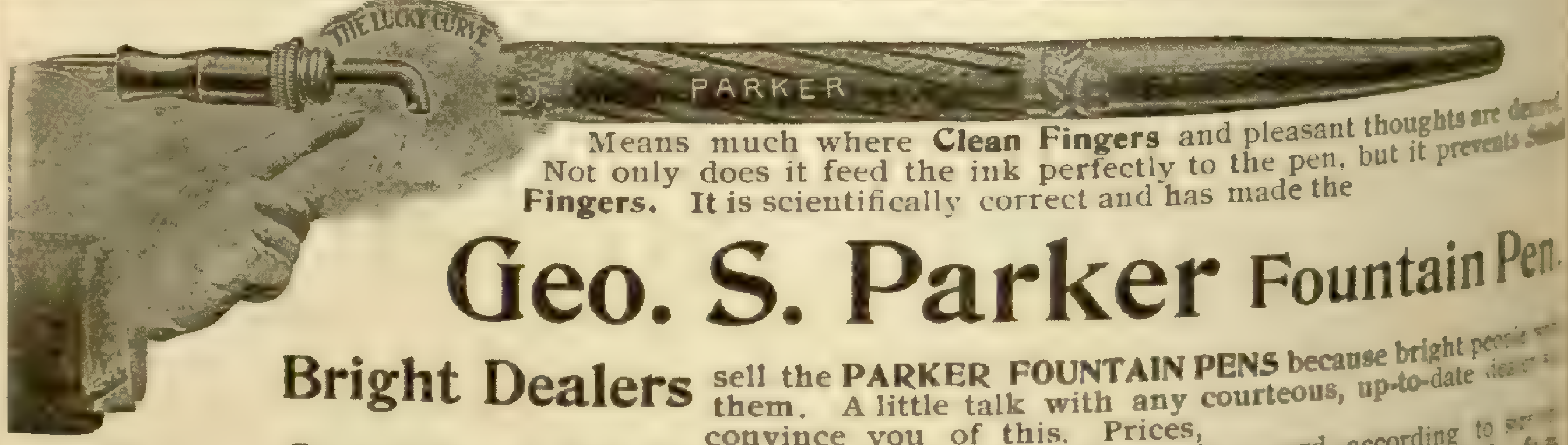

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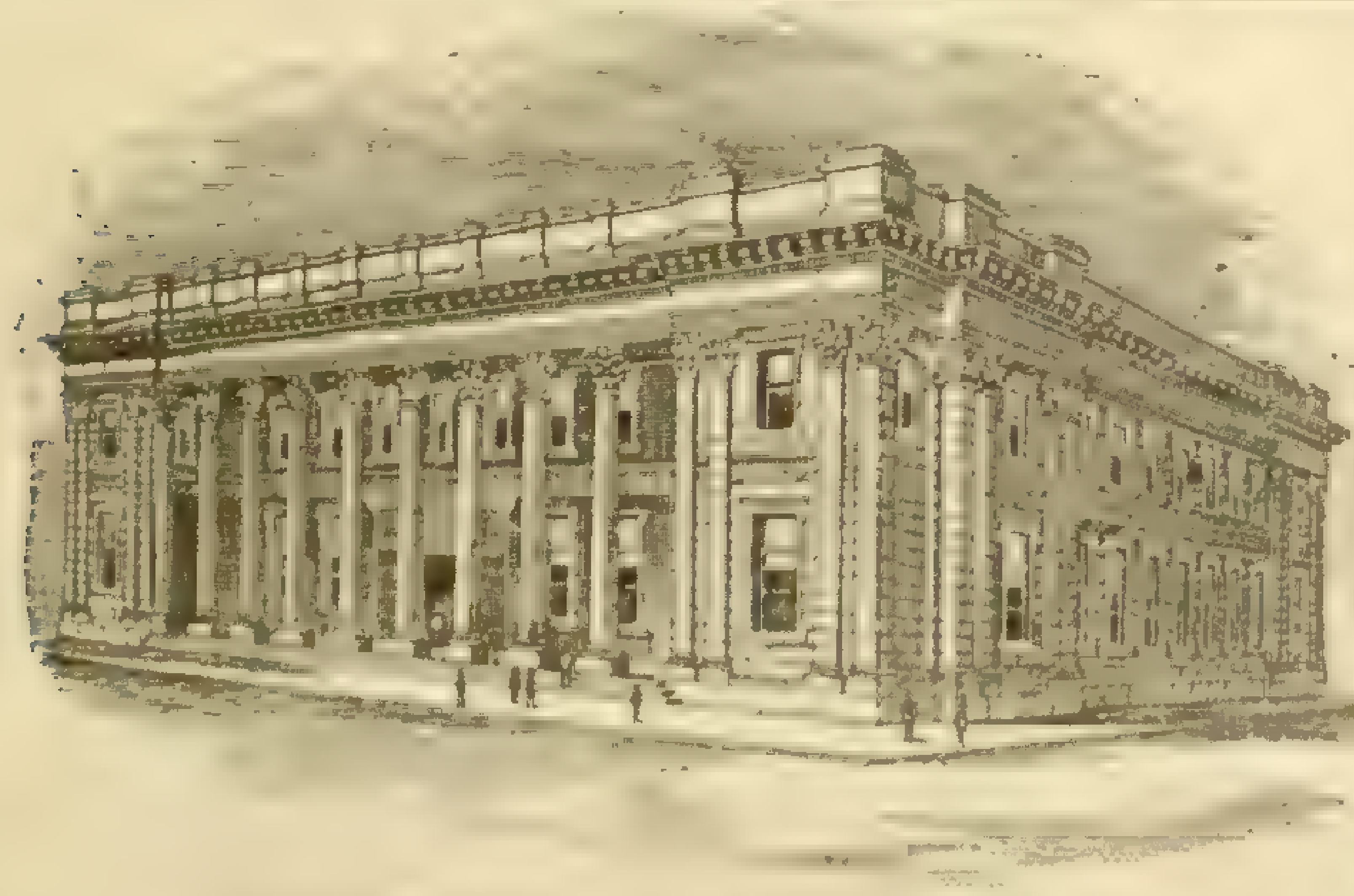

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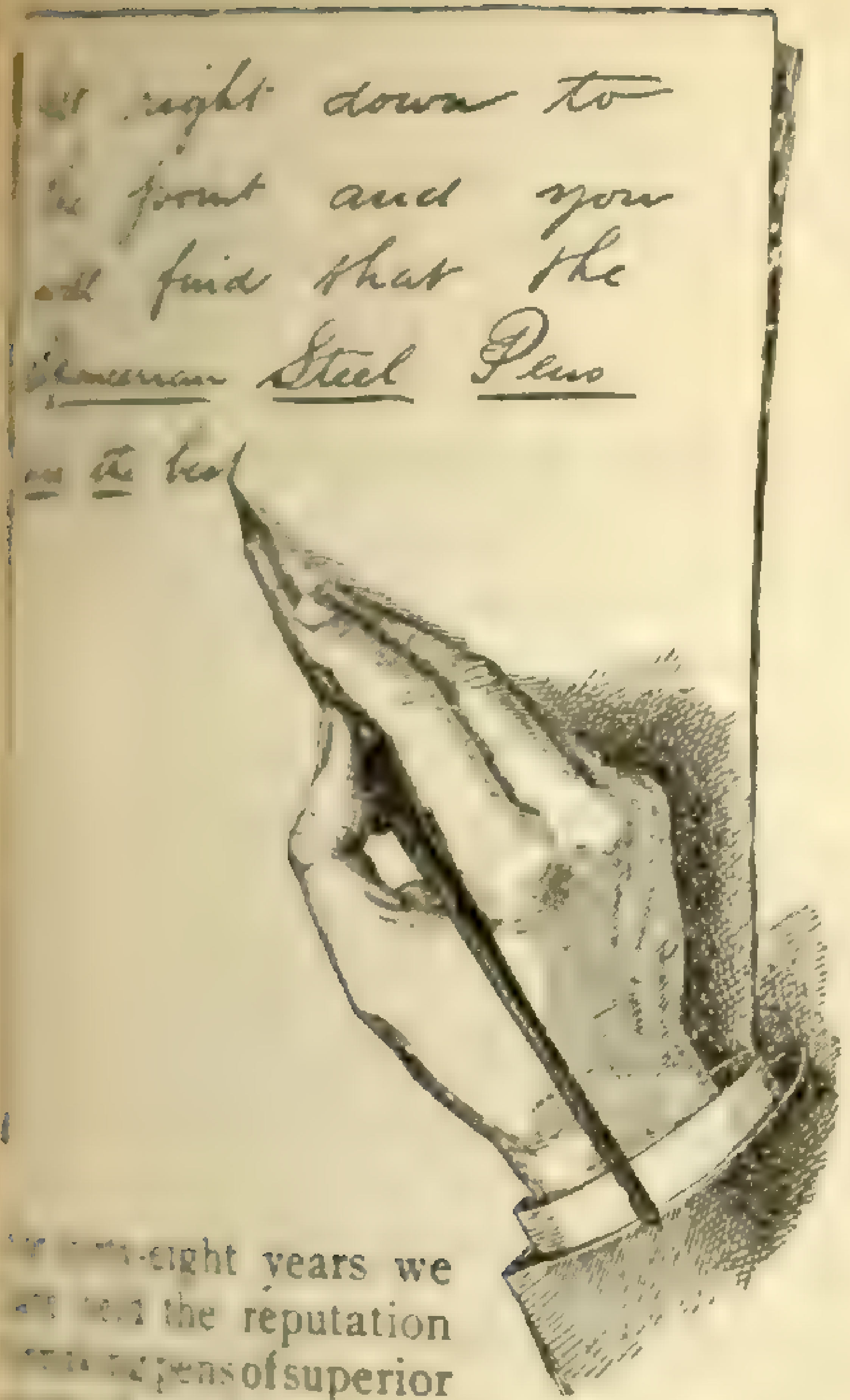
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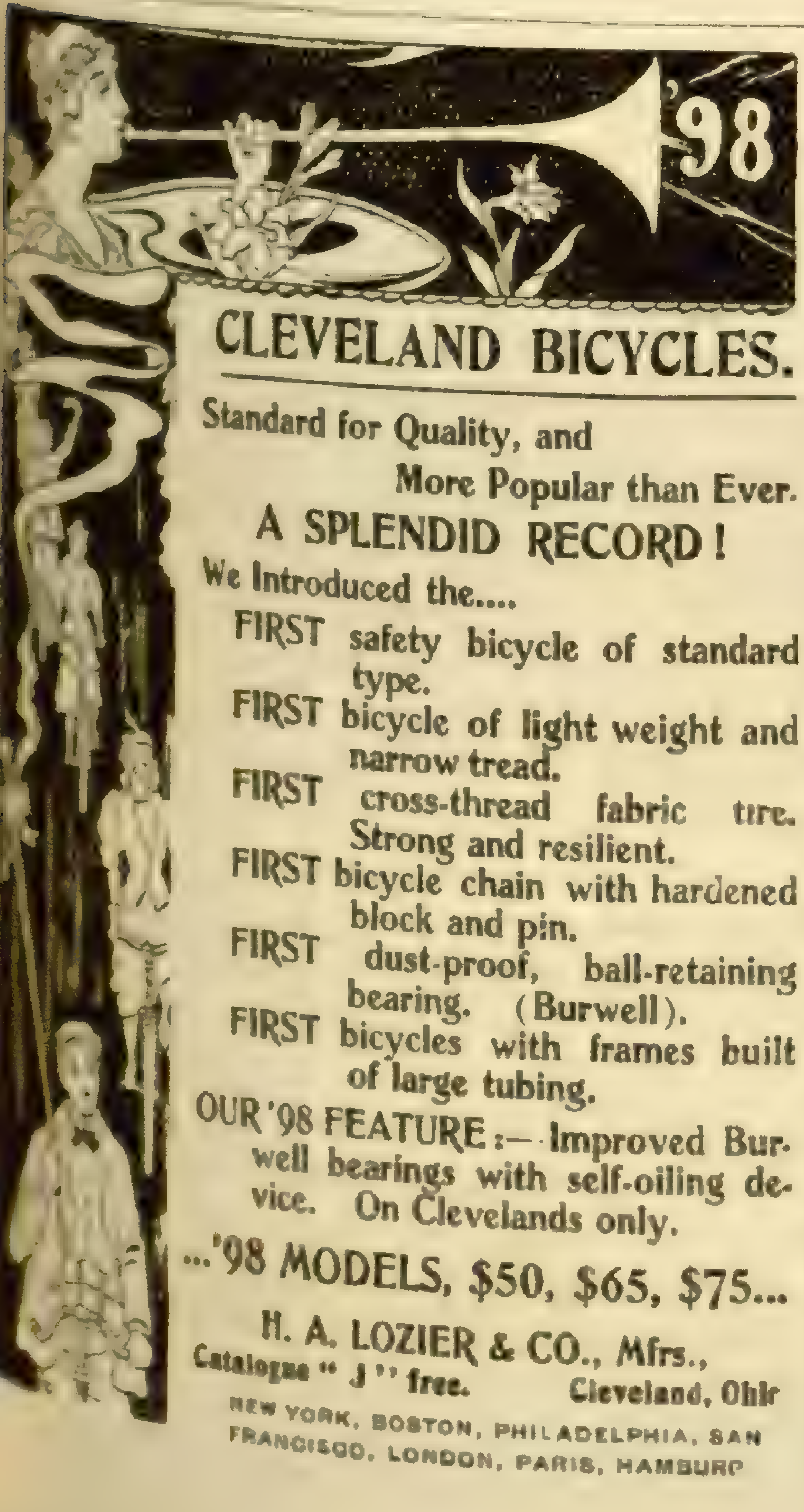

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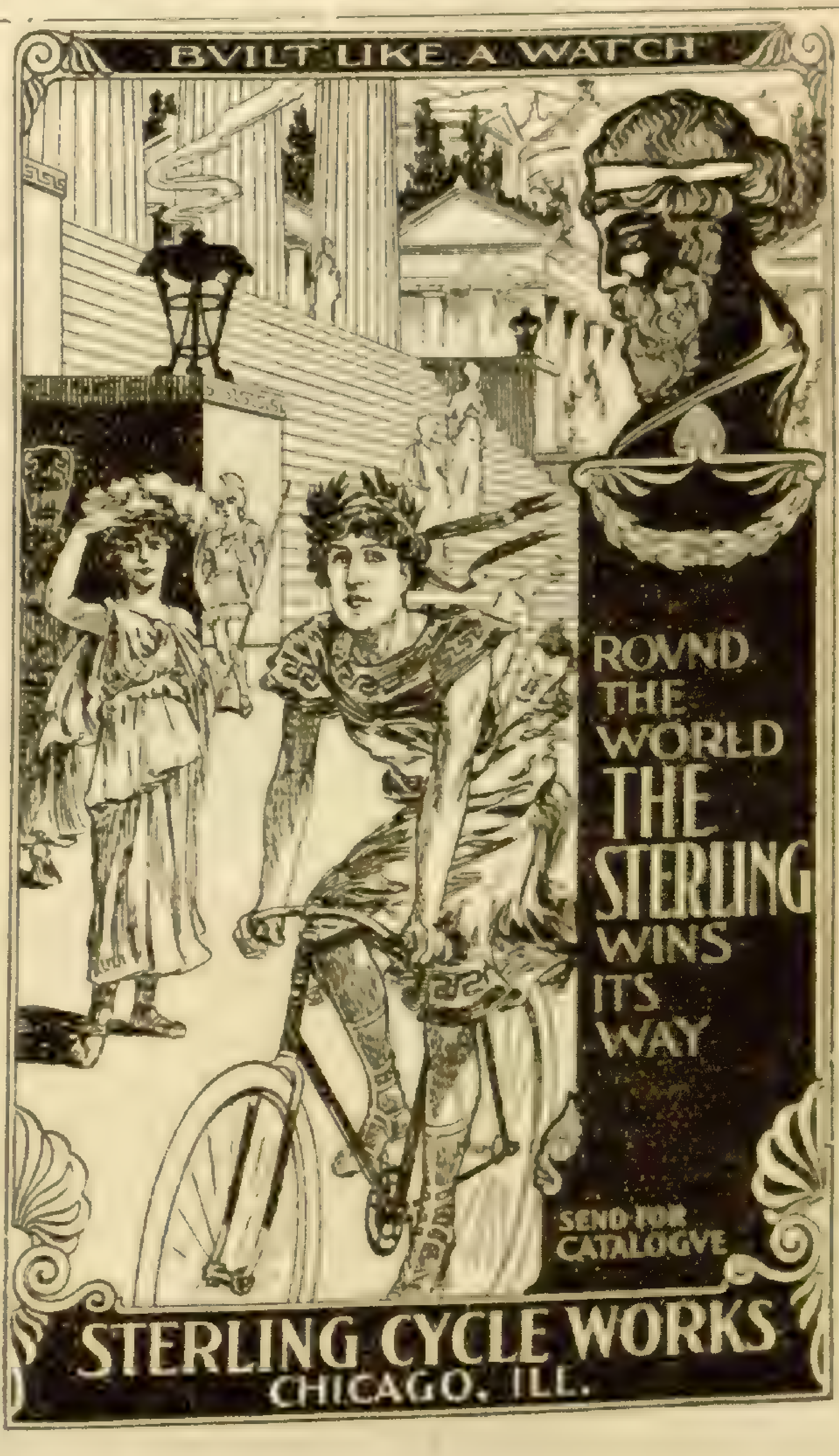
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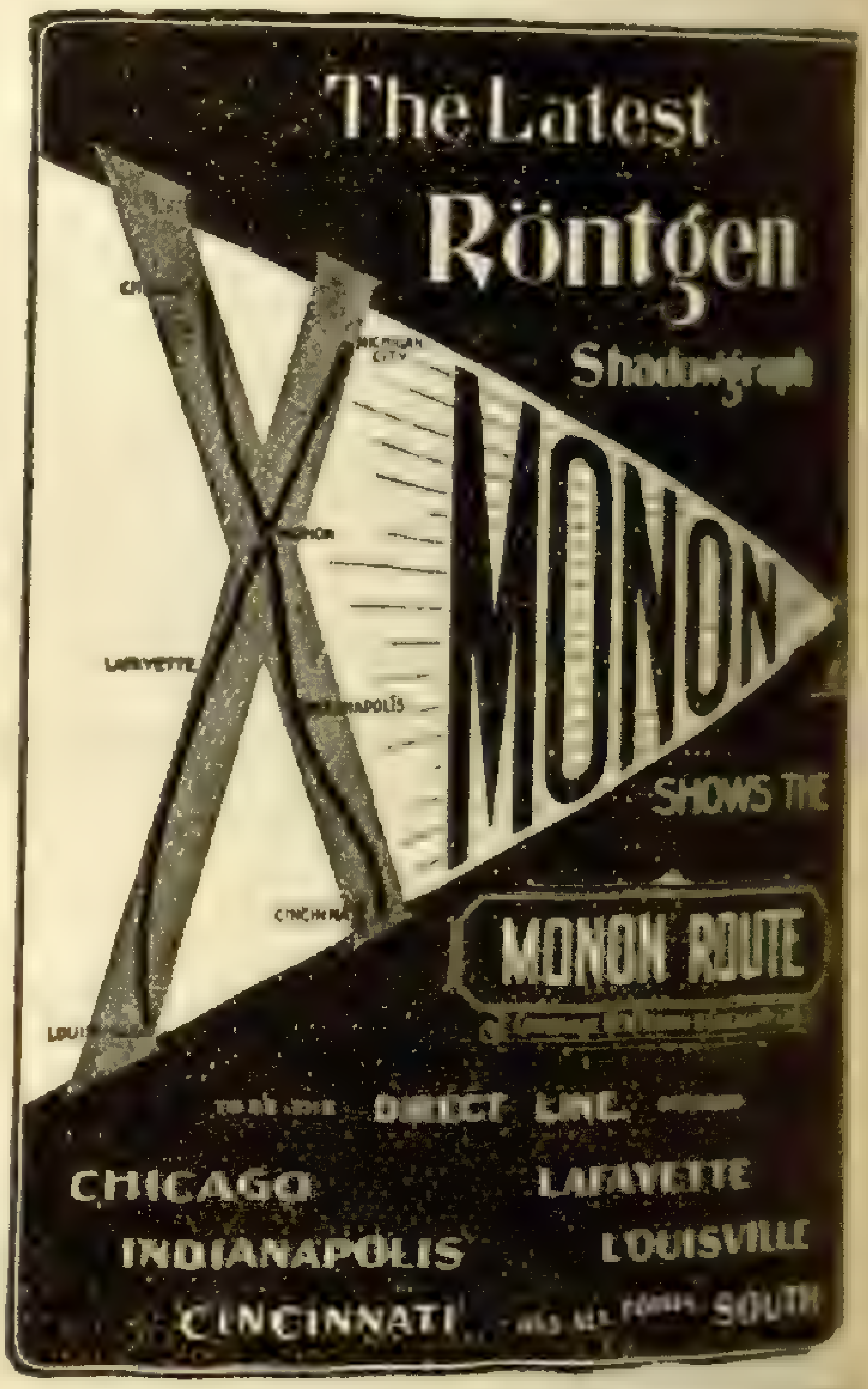

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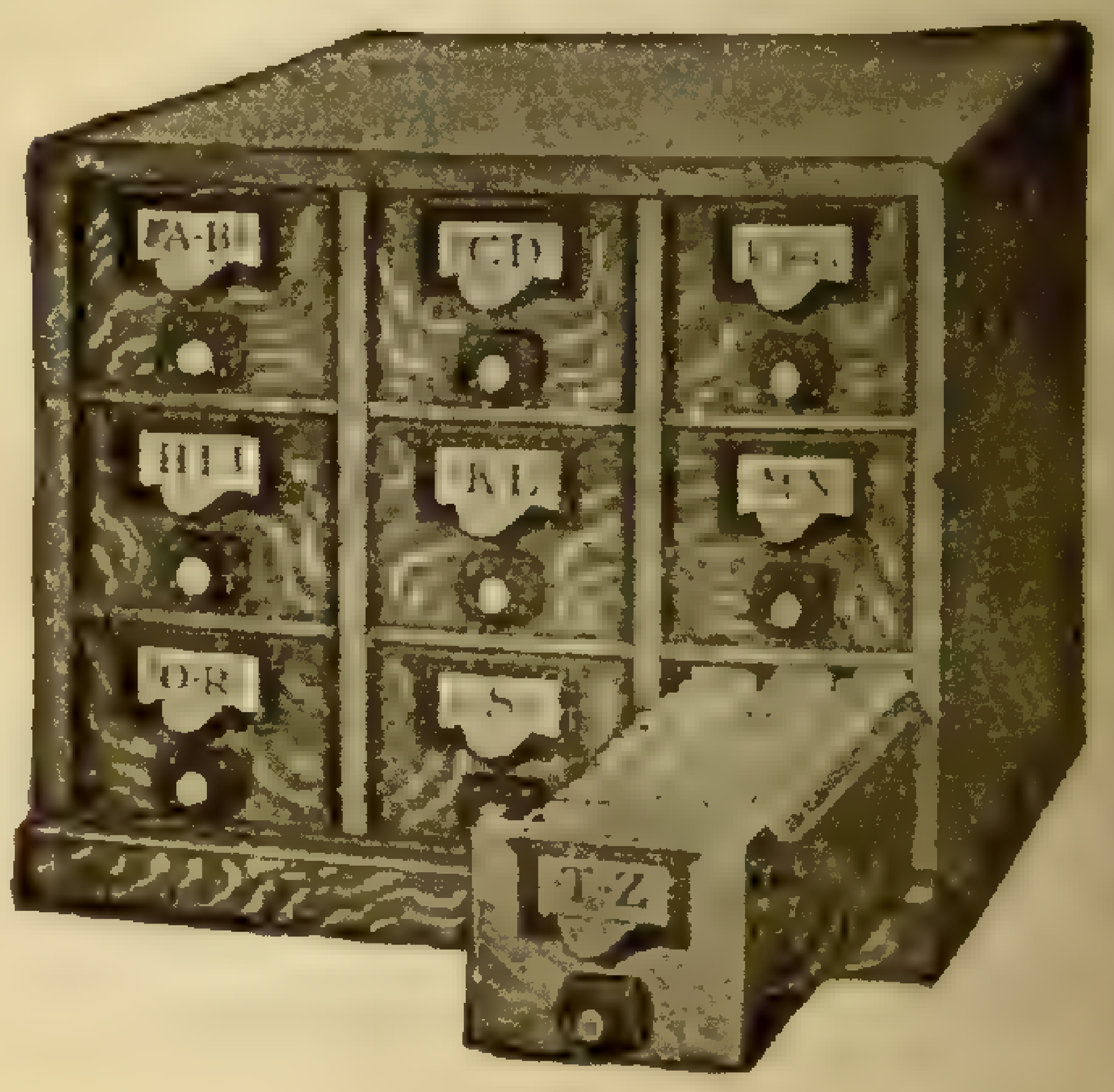

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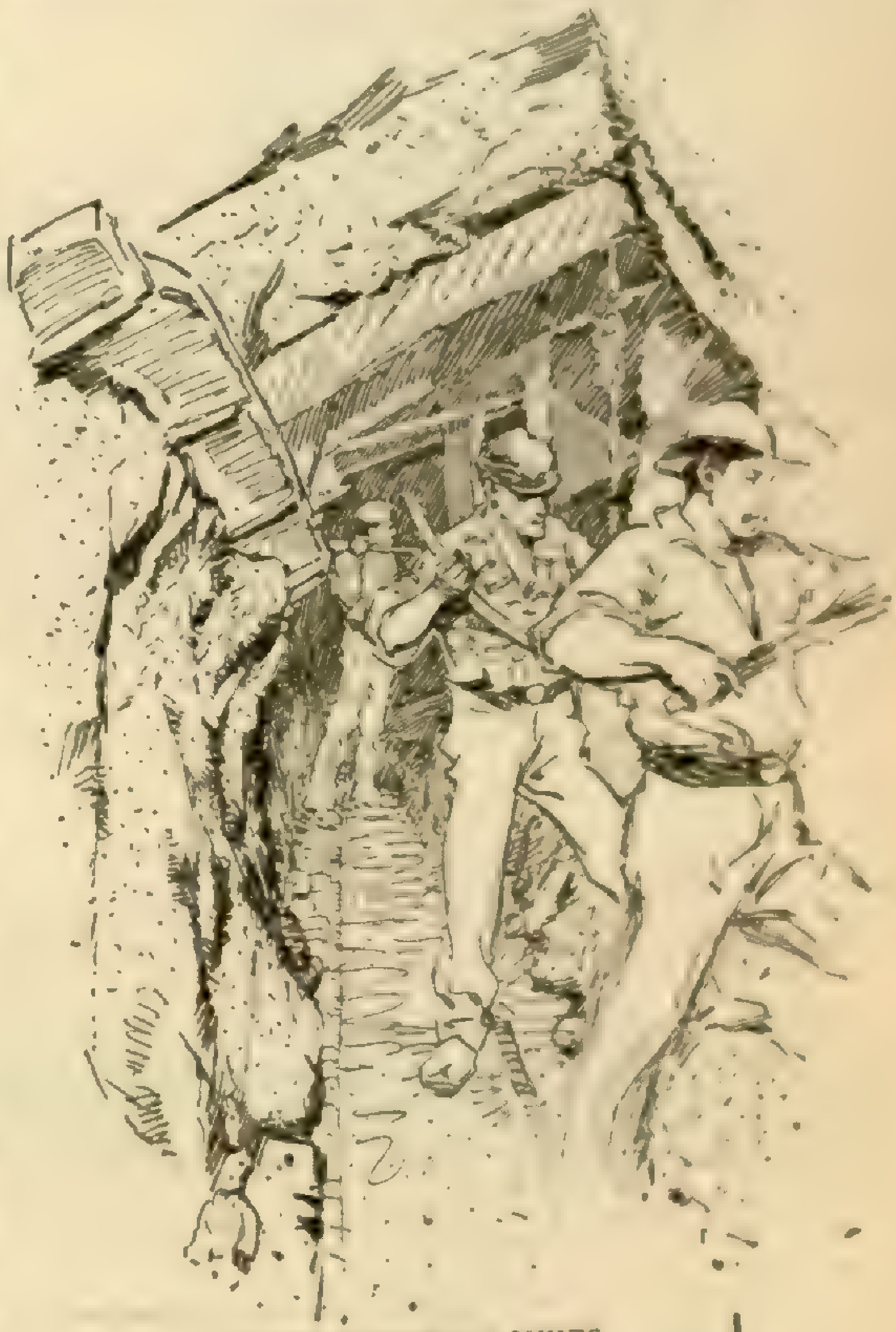

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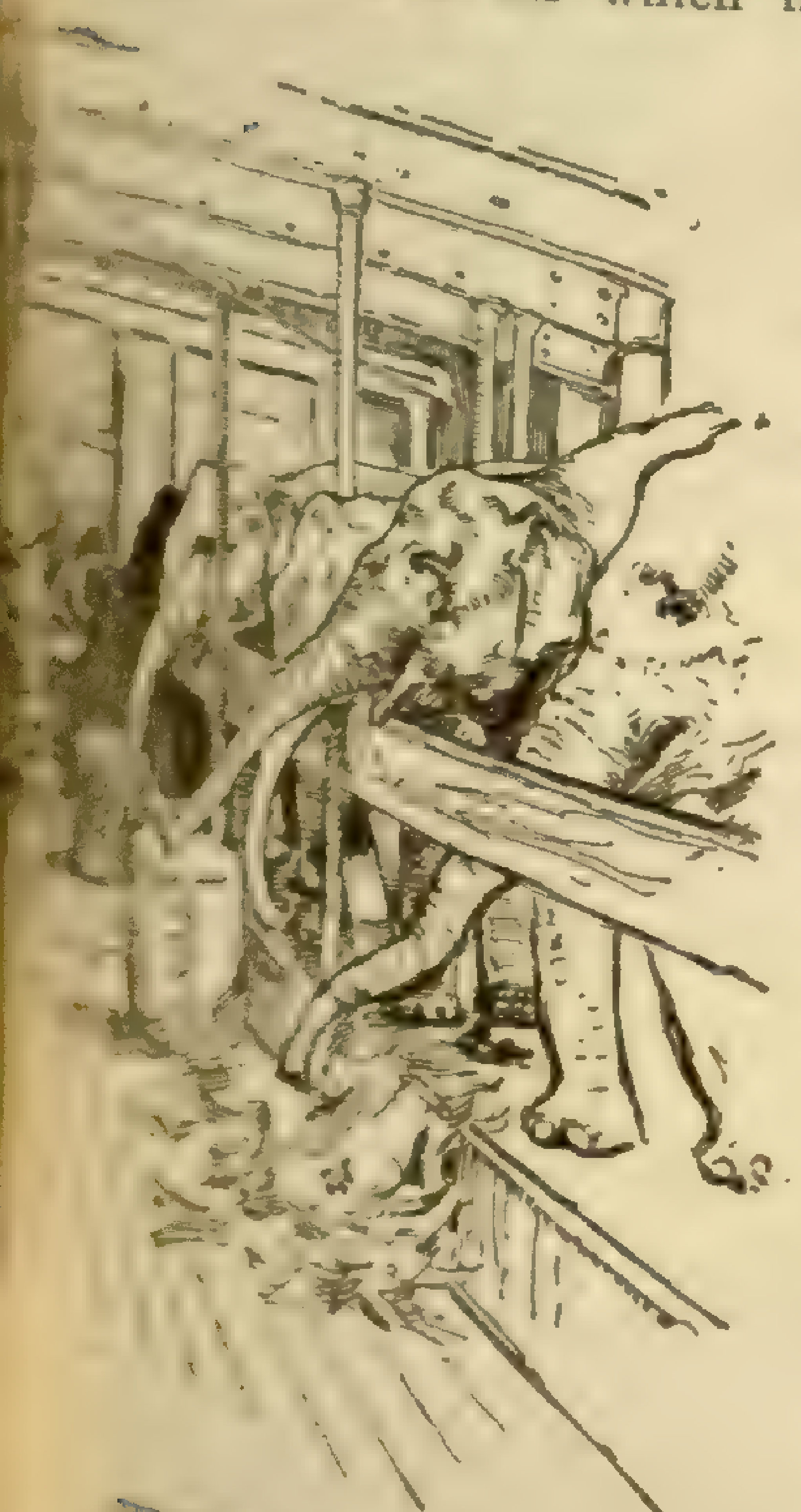

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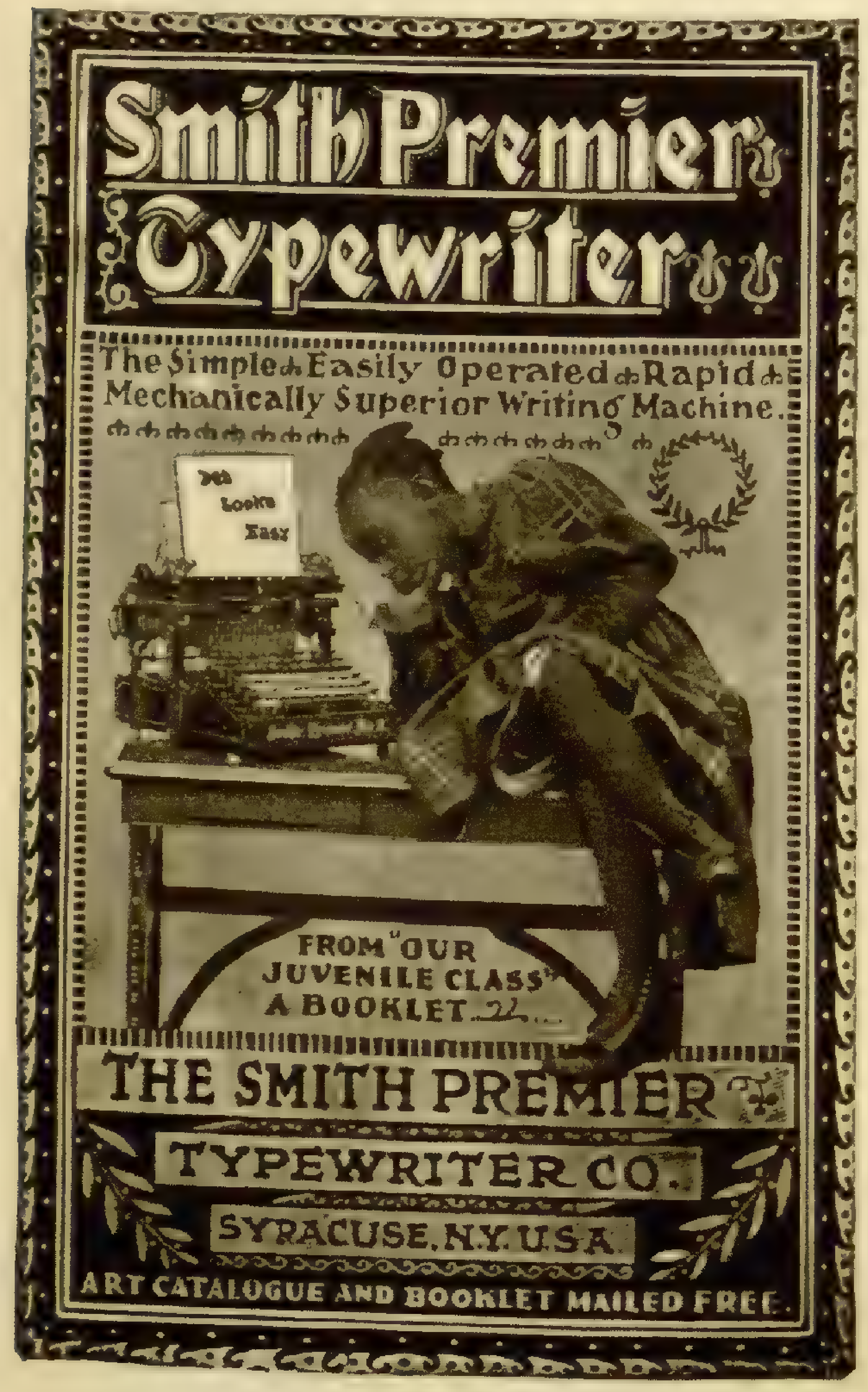

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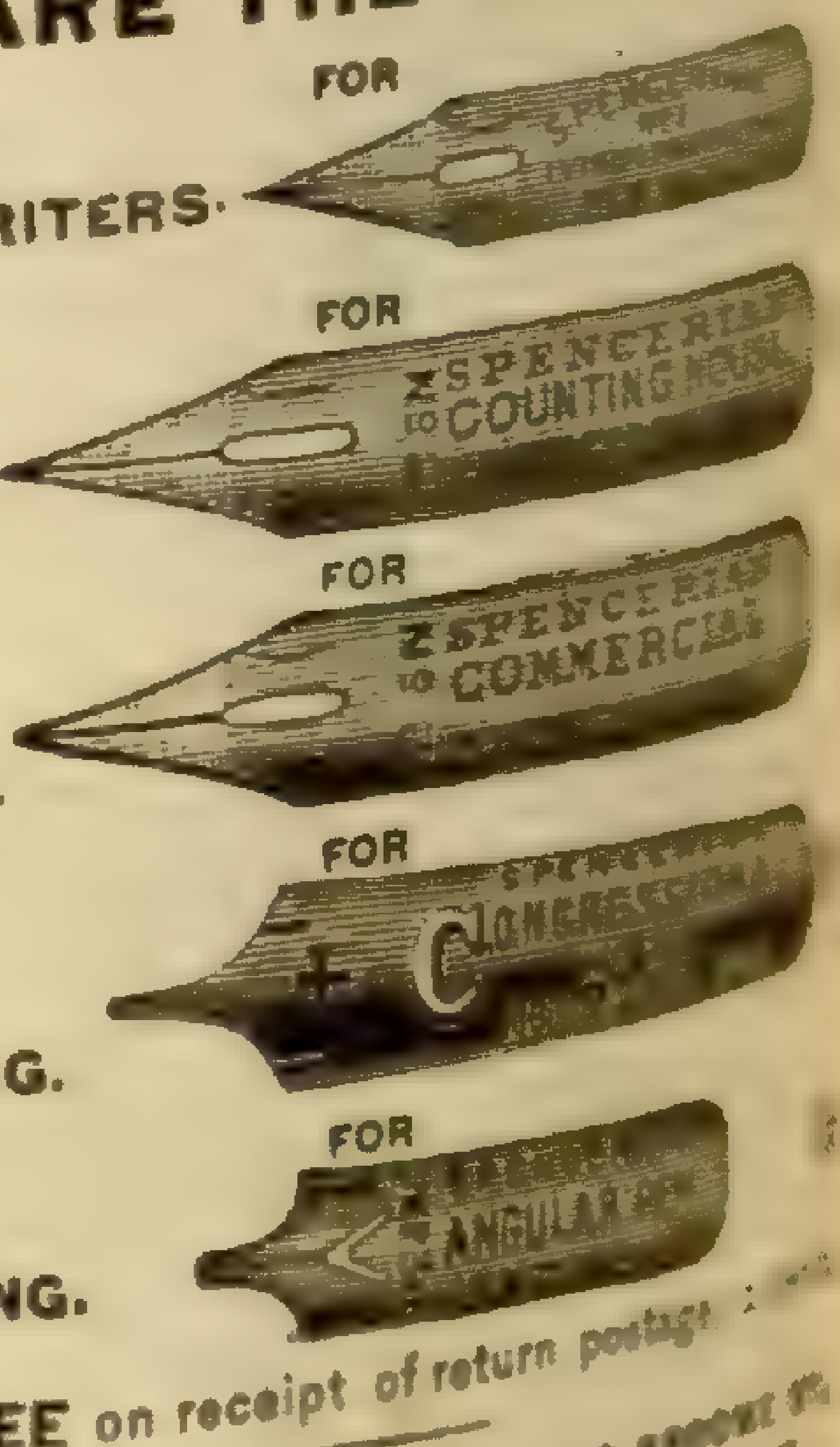

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W. F. GANONG.

(WITH PLATE XVI)

MANY cases of polyembryony are now known, occurring in widely separated groups. Braun, in his summary of the subject in 1860, recorded twenty-one cases in twelve families and thirteen genera, which number has been added to by others. Strasburger was the first to thoroughly investigate its morphological basis, and since his paper in 1878 important contributions have been made to the subject by several investigators, notably Dodel (1890), Overton (1891), Tretjakow (1895), Jeffrey (1895), and Hegelmaier (1897). The results of these works, in so far as they touch this subject, will be found summarized below. In the Cactaceæ, the only case of polyembryony hitherto known has been that of *Opuntia tortispina*, which Engelmann, in his Cactaceæ of Whipple's expedition figured (*pl. 23, fig. 4*) as having two embryos in one seed. This case was cited by Braun (p. 155, *pl. 5, figs. 18–20*), who also suggests that the four cotyledons which he had himself noticed in *Opuntia glaucophylla* may indicate a fusion of two embryos and hence polyembryony, though he points out that it may also be explained as fasciation. While studying the seedling stages in this family, I have found that *Opuntia vulgaris* is markedly polyembryonic, and I may here add that although I have worked over the seedlings of some seventy-five species in this family I have seen no other case of it.

The plants from which my seeds were taken have been growing and flowering luxuriantly for at least four years in the Botanic Garden of Smith College. They agree with the characters given in books for that species, but the source from which they came into the garden is unknown. They set seed every year in great abundance. When the seeds are planted, in a many, perhaps a half, of them more than one seedling comes up and there is the greatest variation in the number, size, and degrees of union with one another of these seedlings. The variety is best made evident by the *figs. 1* to *5*, typical cases drawn the natural size, and of course there are all stages between. I have not tried to follow them further, but what I have noticed seems to show that the larger of a set crowds out the others. It is now important to ascertain the morphological origin of this polyembryony.

The ovule of *Opuntia vulgaris* is at first amphitropous, but in its development it becomes elongated and bent, at the same time turning around in such a way that the funiculus makes a complete turn around it, so that finally it simulates a campylotropous condition (*fig. 6*). Its development in other species of this genus, together with the development of other species of other genera in this family, has been described by d'Hubert, and his account fits this species fairly well. Inside of the funiculus are the integuments, made up of three distinct layers of cells, and inside of these is a nucellus, which becomes absorbed, except for a small portion (at *x*, *fig. 6*), by the embryo as the seed ripens. Finally there is the distinct embryo sac in which there forms after fertilization an abundant endosperm which consists of protoplasts without cellulose walls, the whole of course absorbed by the growing embryo.

In ripe seeds one finds usually a large embryo nearly filling it, with others much smaller and pressed to one side. In half ripe seeds one finds such a condition as is shown in *fig. 8*, where there is one larger embryo with several smaller ones, and usually the larger comes not from the micropylar extremity of the embryo sac, but from some point on its wall a little removed. In other cases one sees a single embryo springing from the micropylar end and one or more from the walls, as in *fig. 7*. Or again, though rarely, there is a single embryo at the micropylar end, as in *fig. 9*. There is a close resemblance between these figures and those given by Strasburger for *Citrus Aurantium* (*fig. 37*). If now these be examined in a still younger stage, it becomes clear that the embryos come from two different positions: first, from a rather irregular mass of tissue which lies at the micropylar end of the embryo sac, and extends thence along its wall; and second, directly from the wall itself. Both of these conditions are well shown in *fig. 10*. It is important to notice, however, that some cases seeming to belong to the latter category belong really to the former, as is illustrated by *fig. 15*, where the wall-standing embryos are shown to spring really from the mass at the micropylar end, but this is not the case with all of the wall-standing embryos, for sections show that in many cases, *i. e.*, *fig. 10*, these are entirely independent of that mass. It is probable that the irregular embryos come as a rule from the micropylar mass, while the regular ones are from the walls, for all I have seen in that position have regularly two cotyledons.

So far, in tracing backwards the origin of the polyembryony, everything is plain, and it is easy to find plenty of cases such as are here figured. At this stage, the entire distinctness of the micropylar mass from the nucellus beneath (see *figs. 10* and *11*) and its close resemblance to that described and figured by Jeffrey which he traced to its origin in a fertilized egg cell, would lead one to suppose that we have here a similar case; while in the wall-standing embryos, which are so sharply distinct from the nucellus (*fig. 11*) that an origin from nucellus seems excluded, only an origin from an endosperm cell would appear possible, a condition which is yet unknown.[1] But the earlier stages show that both of these suppositions are incorrect. In a great

[1] This was my own opinion in both cases at the time this paper was read before the

abundance of material which shows the ovules in all stages before and at the time of fertilization, and also all stages after that represented in *fig. 10*, I was able to find, after prolonged and careful search, only three cases which show the origin of the embryos, but happily they leave no doubt on the subject. I think this stage must be passed through very rapidly, and perhaps at night, when none of my material was collected.

In stages earlier than *fig. 10*, the pollen tube can usually be seen in the micropylar region of the nucellus, but an egg cell cannot be detected. Instead there regularly lies in its position a crumpled mass of protoplasm (*fig. 12, 14, pr.*), shrunken in my material by the weak alcohol used to preserve it. I think the egg cell disappears early in the development of the ovule, a point which will be cleared up by a complete study of the development of the embryo sac, now being made by one of my students. At all events there is certainly no egg cell present in any of my preparations at the period when the embryo building begins. The nucellus cells near the pollen tube are rich in contents, and in one case (*fig. 12*) I have found these beginning to bud out into the embryo sac. That these represent the beginning of the formation of the micropylar mass, I think there can be no question. It is precisely in this way that the adventitious embryos originate in Funkia and other cases, as described so fully and clearly by Strasburger. In another case (*fig. 13*) there are present not only the richly protoplasmic nucellus cells near the pollen tube, here, however, not budding, but also other nucellus cells a little removed and separated by a space filled with cells rather poor in contents; and these cells with rich contents are also distinctly budding out (*fig. 13, x*). Now these, I believe there can be no doubt, are the beginning of the wa-standing embryos; it is quite probable that at first they are continuous with those near the pollen tube, but are removed from them by the growth in length of the embryo sac, which at th time is very rapid. At all events they are nucellus cells. Th

Society for Plant Morphology and Physiology, Dec. 29, 1897. I had not then found the three cases next to be described, which prove the origin to be different.

third case I have found is represented in *fig. 14*, which is more advanced than *fig. 13*, and where the differentiation of the richly protoplasmic cells of the embryonic mass from the nearly empty cells beneath it is fairly sharp, but nevertheless the relations of the two kinds are still sufficiently close to show the origin of the one from the other. Another section of the same specimen shows a similar connection of the other mass of embryonic tissue with the nucellus.

From these cases it is clear that in this species the embryos of both positions arise from the nucellus, and in this respect agree with Funkia, Nothoscordum, Citrus, and others, the usual method.

A synopsis of the modes of origin of polyembryony is given by Tretjakow, which in synopsis, with the additions made by others, and excluding cases due to branching of the nucellus, union of two ovules, presence of two or more embryo sacs in one nucellus, etc., are as follows: From cells of nucellus near the micropyle, *Funkia* and others (Strasburger); from a second egg cell, *Santalum*, or from its doubling *Sinningia* (Strasburger); from synergids, *Mimosa Denhartii* (Guignard), *Iris Sibirica* (Dodel), and perhaps in *Lilium Martagon* (Overton); from the antipodals and synergids, *Allium odorum* (Tretjakow); from the branching of a mass of tissue derived from the fertilized egg cell (Jeffrey); finally, Hegelmaier points out the occurrence in *Allium odorum* of embryos from egg cell, synergids, antipodals and nucellus cells, all in the same species and individuals. There still remain as possible origins, endosperm and integument. In all known cases except *Cœlebogyne*, the production of the new embryos takes place only after fertilization, or at all events after the entrance of the pollen tube.

A question of great interest now arises as to the significance of polyembryony. Strasburger, though he mentions that it recalls apogamy, then recently discovered by Farlow, contents himself with referring to the extra embryos as "Adventivknospen" or "vegetative Adventivkeime." Pfeffer[2] has suggested that it is but a case of budding, and that the specific conditions

[2] Pflanzenphysiologie 1: 29. 1897.

in the embryo sac determining the form of the sexually produced embryo, give the same form to the adventitious embryo. Tretjakow suggests that the development from the antipodals represents apogamy, the antipodals being homologous with the vegetative cells of the prothallus, but this explanation will not apply to the origin from nucellus cells. Jeffrey has nothing to say on this point, while Hegelmaier concludes his paper thus:

> Die verhältnissmässige Seltenheit der dem Eiapparat entspringenden Polyembryonie bei *A. odorum* einerseits und das öftere gelegentliche Vorkommen dieser Form̄ bei verschiedenen anderen Pflanzen andererseits könnte vielleicht zu der Auffassung führen, dass ihr Vorkommen bei unserer Pflanze überhaupt nicht in dieselbe Reihe mit dem Vorkommen der anderen Formen von Polyembryonie bei ihr zu stellen und ihr Zussammentreffen mit diesen anderen Formen mehr nur ein zufälliges sei. Aber mindestens für diese letzteren ist doch wohl die Annahme unabweisbar, das irgendwelche gemeinschaftlichen Ursachen vorhanden sein müssen, für deren Erkenntniss durch ein Spiel mit morphologischen Homologien nichts zu gewinnen sein würde.

In general for a new feature one of three origins may be supposed. First, it may be some incidental growth or functional condition. Here comes the explanation of budding, and Pfeffer's explanation of the assumption of the embryo form through specific qualities of the embryo sac. But polyembryony seems too distinct and elaborate a process to be thus explained. Second, it may be a relic of some older condition now disappearing. But its very different morphological origins are against this. Here comes its explanation as apogamy, but this does not explain the origin from the nucellus. Third, it may be the early stages in the development of something new. It can hardly yet be of any service to the plants, for many of the embryos are absorbed before the seeds are ripe, and in other cases usually but one develops, though perhaps one of the smaller may sometimes take the place of the leader if this is destroyed. Its origin in several distinct groups and by several distinct methods seems to imply that there is some virtue in the development of the extra embryos, and that their appearance is controlled by that influence, whatever it may be, which is much more powerful than mere morphological inertia, and which elsewhere forms new structures from the most different morphological origins. In its independent appearance in distinct groups it is comparable with the appearance of heterospory, but whether polyembryony like heterospory will lead to some higher condition remains to be seen, though we shall not see it.

SMITH COLLEGE, NORTHAMPTON, MASS.

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A fuller bibliography and references may be found in Tretjakow.

EXPLANATION OF PLATE XVI.

Figures all drawn with camera lucida, and the original drawings reduced one-half.

In all of the figures, *e. s.* = embryo sac ; *n.* = nucellus ; *in.* = the integuments collectively ; *i. i.* = inner integument ; *m.* = micropyle or micropylar opening through the nucellus ; *p.* = pollen tube ; *pr.* protoplasm of embryo sac.

FIGS. 1, 2, 3, 4, 5, each showing the embryos from a single seed, natural size.

FIG. 6. Median section through an ovule of *Opuntia vulgaris*, somewhat diagrammatized, six times natural size : *f* = funiculus ; *a* = attachment of funiculus to ovule ; *x* = portion of nucellus not absorbed when seed is ripe.

FIG. 7. Embryo sac showing three embryos, one from the micropylar end and two from the wall. × 18.

FIG. 8. Embryo sac showing one large embryo on the wall and several smaller from the micropylar end. × 18. Not a section, but a half seed laid open.

FIG. 9. Embryo sac showing a single embryo from the micropylar end. × 35.

FIG. 10. Embryo sac showing embryos on the wall together with the branching mass from the micropylar end. Nucellar cells drawn nearly exactly; those of embryos exact on the outside but only approximate in the interior. × 90.

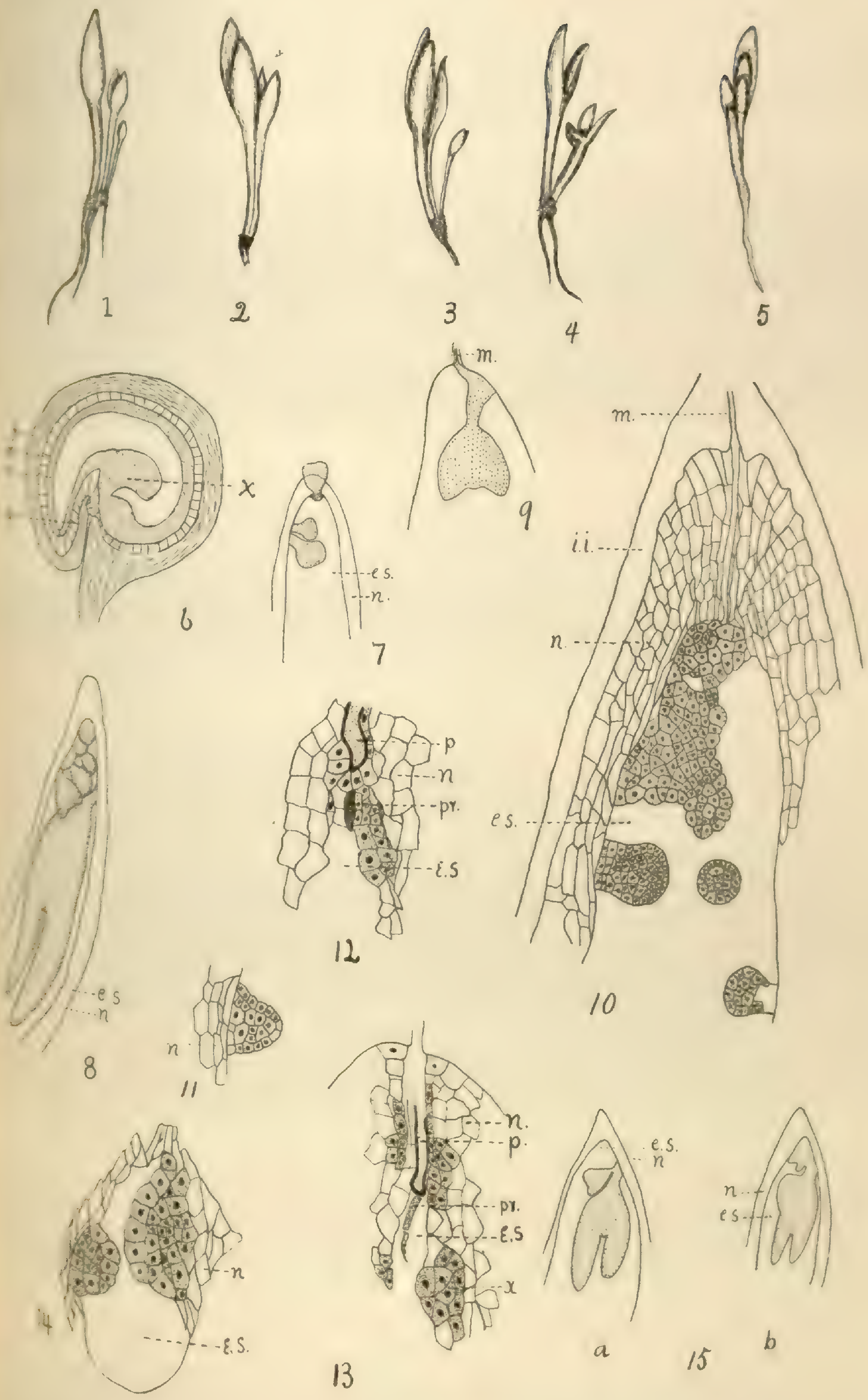
FIG. 11. An embryo on the wall; to show the connection of cells of embryo to those of nucellus; a microtome section. × 90.

FIG. 12. Beginning of budding from nucellus cells near the micro × 90.

FIG. 13. Cells of nucellus beginning to grow out at x into an embr × 90.

FIG. 14. Embryonic mass separating from the nucellus. The section is cut diagonally through the apex of the embryo sac. × 90.

FIG. 15. *a, b.* Two sections from one embryo sac to show that some apparently wall-embryos are really from the micropylar mass. × 18.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GANONG on POLYEMBRYONY.

FLOWERS AND INSECTS. XVIII.

CHARLES ROBERTSON.

ACTÆA L.— *A. spicata* L. is a white pollen-flower with incomplete proterogyny, though Axell regarded it as homogamous. Dr. Buddeberg's observation at Nassau of the visits of *Byturus fumatus* F. (Dermestidæ) and *Forficula auricularia* L. (Orthoptera) hardly indicates more than partial investigation or unfavorable conditions (4).

ACTÆA ALBA Bigel.— This agrees with observations made on *A. spicata*, of which it has been regarded as a mere variety.

The plant is rather rare, in low rich woods, rising 4–5^{dm} and bearing short racemes. The sepals fall when the flower opens. The numerous stamens and the stigma are white and are the most conspicuous parts, the slender petals being of little use. The ovary is surmounted by large two-lobed stigma, which is receptive before the anthers open. The stamens are turned to a more or less horizontal position, so that, after the anthers open, the insect visitors are likely to touch the stigma before being dusted with pollen. The flowers open almost simultaneously. The proterogyny is incomplete, nectar is wanting, and the insects abandon the flowers as soon as the pollen is gone.

From their white color, small size and nectarless condition, the flowers seem to depend upon the females of small species of Halictus, by which they are abundantly visited. The blooming season is from May 3 to 23, a plant found in bloom on June 20 seeming quite an exceptional case. On May 8 the following visitors were observed :

Bees—*Andrenidae* : (1) Andrena sp. ♀, c. p. ? ; (2) Halictus pectoralis Sm. ♀, c. p., ab.; (3) H. zephyrus Sm. ♀, c. p.; (4) Augochlora confusa Rob. ♀, f. p.

On the pollination of Actæa see :

(1) Axell, Om anordningarna för de fanerogama växternas befrukt 60, 104. 1869.—(2) Ricca, Osservazioni sulla fecondazione incrociata vegetali alpini e subalpini. Atti Soc. Ital. Sci. **13**:254. 1871; **14**:240. *A. spicata*, distinctly proterogynous. cit. by Delpino.—(3) Delpino, Ulter osservazioni II. **2**:178. Atti Soc. Ital. Sci. **16**:326. 1873. *A. sp* probably macrobiostigmatic.—(4) Müller, Weitere Beobachtungen 1 1878.—(5) Kirchner, Beiträge zur Biologie der Blüten. Progr. 72 Jahres Kgl. Württemb. landwirtschaftl. Akad. Hohenheim 18. 1890. *A. sp* (Just **18**¹:492).—(6) Kerner, Pflanzenleben **2**:—. 1891. Oliver translat **2**:183, 310. 1895. *A. spicata*, attractive stamens, etc.

LESPEDEZA PROCUMBENS Michx.—The flowers are brigh purple, especially the vexillum. There is a white triangular mar at base of the latter forming a pathfinder. The stamens a pistil are protected by the keel, which at first returns to position when depressed. The stigma strikes the visitor advance of the anthers. The calyx and claw of the banner a short, so that a tongue $2–3^{mm}$ long can exhaust the nectar.

The blooming season is Aug. 2–Sept. 21. On Aug. 14 and 15 the following visitors were observed:

Bees—*Apidae:* (1) Megachile brevis Say ♀, s. & c. p.; (2) Ammobat illinoensis Rob. ♂♀, s.; (3) Calliopsis andreniformis Sm. ♂♀, s.; *Andrenidae* (4) Halictus confusus Sm. ♀, s. & c. p.; (5) Augochlora confusa Rob s. & c. p.

Diptera—*Bombylidae:* (6) Systoechus vulgaris Lw., s.

Lepidoptera—*Rhopalocera:* (7) Lycaena comyntas Gdt., s.

LESPEDEZA RETICULATA Pers.—*L. Virginica* (L.) Britt.—The plants grow $3–4^{dm}$ high, are very leafy and rather densely co ered with rose-colored flowers. The flower is about 5^{mm} lon the calyx tube about 2^{mm}, and the claw of the banner abo 1.5^{mm}.

The blooming season is July 30–Sept. 14. On Aug. 22, 2 29, 31, and Sept. 2, 4, 7 the following visitors were observed

Bees—*Apidae:* (1) Bombus americanorum F. ♂☿, s. & c. p., freq Anthophora walshii Cr. ♀, s.; (3) Melissodes nivea Rob. ♀, s. & c. p. Megachile optiva Cr. ♀, s. & c. p.; (5) M. brevis Say ♂♀, s. & c. p., a (6) M. latimanus Say ♀, s.; (7) Coelioxys totonaca Cr. ♀, s.; (8) Epe concavus Cr. ♀, s.; (9) E. lunatus Say ♀, s.; (10) Calliopsis andreniform Sm. ♂♀, s.; (11) Panurginus compositarum Rob. ♂, s.; *Andrenidae*:

Halictus ligatus Say ♀, s.; (13) Augochlora confusa Rob. ♂, s.; (14) A. similis Rob. ♂, s.; (15) Colletes americanus Cr. ♂, s.

Lepidoptera — *Rhopalocera:* (16) Lycaena comyntas Gdt., freq.; (17) Thecla melinus Hbn.; (18) Colias philodice Gdt.; (19) Pamphila cernes Edw.— all s.

Lespedeza capitata Michx.— The flowers are white, pink streaks on the base of the banner forming pathfinders. The wings and keel are depressed together and return to their position covering the stamens and pistil. The claw of the banner is so long that a proboscis 3–4 mm long is needed to reach the nectar. Its infolded edges guide the bee's tongue to the opening in the stamen tube.

The blooming season is Aug. 14–Sept. 11. On Aug. 14 and 23 I saw the flowers visited by two bees: *Megachile brevis* Say ♀, s. & c. p., and *Calliopsis andreniformis* Sm. ♂, s.

On the pollination of Lespedeza see:

(1) Berkeley, Sterility — constitutional and organic. Gardener's Chronicle 1: 36. 1855. Cleistogamy, both kinds of flowers simultaneous. Cit. by Henslow.—(2) Kuhn, Einige Beobachtungen über Vandellia und den Blüthenpolymorphismus. Bot. Zeit. **25**: 67. 1867.—(3) Axell, Om anordningarna för de fanerogama växternas befruktning 11. 1869. Cites Kuhn.—(4) Henslow, On the self-fertilization of plants. Trans. Linn. Soc. II. Bot. 1: 327. (1877) 1880.—(5) Foerste, Notes on structures adapted to cross-fertilization. Bot. Gaz. **13**: 152. 1888. *L. violacea* (Just **16**^{1}: 533).

Cornus L.— The flowers are perfect. According to Gray's Manual some foreign species are dioecious. In the Tyrol Schulz (12) failed to verify the observation of Hausmann that *C. Mas* is dioecious or polygamous. From the condition of certain examples of *C. Canadensis* after flowering Meehan (14) inferred that this species is monoecious and dioecious.

The flowers have four petals, four stamens, a single style with terminal or capitate stigma, the base of the style being surrounded by an epigynous nectar disk.

One group of Cornus consists of species whose flower clusters are surrounded by an involucre, which is usually white. In these the petals are less conspicuous, and, at least in some cases, less expanded, so that they limit access to the nectar.

In the other group the conspicuousness of the inflorescence depends upon the individual flowers, whose petals are white and widely expanded. The nectar is therefore freely exposed.

The flowers are homogamous. In *C. sanguinea* Müller (4, 8) observed that insects may effect cross or self-pollination, and in their absence that spontaneous self-pollination or geitonogamy may occur.

Sprengel (1) observed that *C. sanguinea* was visited by a variety of insects. Müller's list shows fourteen beetles, five flies and one Pompilus. Delpino (3) includes this species in his "Tipo idrangeino," which he regards as adapted to beetles.

CORNUS FLORIDA L.—Kerner (13) supposes that the bracts serve as attractive organs and as landing places for insects. But insects visiting the flowers seldom alight on them. He also mentions what he calls "arrangements for geitonogamy," which seem to me to be quite imaginary.

This small tree occurs in only one place in my neighborhood. A dozen or more flowers are collected in a head. The four scales of the hibernaculum, which encloses the developing head, greatly elongate and expand at base, at the same time assuming a white or pinkish color. Very frequently the two inner scales remain united, so that by their basal expansion they form an arch over the head. These parts are often folded inwards in the middle, with the result that the head is often more conspicuous laterally than would be the case if all of the scales were expanded horizontally.

Nectar is secreted by an epigynous disk. The calyx tube is about 1^{mm} deep. This with the four petals and four filaments has the effect of concealing the nectar in a tube about 2^{mm} deep.

The petals are greenish yellow, their tips being reflexed, the flower expanding about 4^{mm}. The stamens are strongly divergent and are exserted about 4^{mm}, the style projecting little more than 1^{mm}.

The flowers are homogamous. Insects crawling about over the inflorescence get their heads and undersides covered with pollen. On sucking they easily effect pollination. In their absence spontaneous self-pollination or geitonogamy may sometimes occur by the pollen falling upon the stigmas. In Cornus and Viburnum the elongation and strong divergence of the stamens is no kind of an "arrangement for geitonogamy," though it may result in that, but merely places the anthers in position to strike insects which run about irregularly over the flowers.

The flowers were noted in bloom from April 22 to May 8. In this time very few of the lower aculeate Hymenoptera are flying. The following list, observed on April 23, showing a strong preponderance of Andrenidae, with flies less abundant, is about what might be expected from the structure of the flowers and the composition of the insect-fauna at the blooming time:

Hymenoptera—*Apidae:* (1) Bombus separatus Cr. ♀, s., one; (2) Osmia albiventris Cr. ♀, s. & c. p., one; (3) Nomada sayi Rob. ♂, s.; *Andrenidae:* (4) Halictus foxii Rob. ♀, s. & c. p.; (5) H. coriaceus Sm. ♀, s.; (6) H. fasciatus Nyl. ♀, s. & c. p., freq.; (7) H. pilosus Sm. ♀, s. & c. p.; (8) H. zephyrus Sm. ♀, s.; (9) H. confusus Sm. ♀, s.; (10) H. obscurus Rob. ♀, s. & c. p.; (11) H. stultus Cr. ♀, s. & c. p., freq.; (12) Agapostemon radiatus Say ♀, s.; (13) Augochlora pura Say ♀, s. & c. p.; (14) A. confusa Rob. ♀, s. & c. p.; (15) Andrena vicina Sm. ♀, s.; (16) A. bipunctata Cr. ♂ ♀, s. & c. p., freq.; (17) A. rugosa Rob. ♂ ♀, s.; (18) A. claytoniae Rob. ♀, s. & c. p., freq.; *Vespidae:* (19) Polistes metricus Say, s.; *Eumenidae:* (20) Odynerus foraminatus Sauss., s., one.

Diptera—*Empididae:* (21) Empis humilis Coq., freq.; *Bombylidae:* (22) Bombylius pulchellus Lw.; (23) B. major L.; *Syrphidae:* (24) Chilosia capillata Lw.; (25) Mesograpta marginata Say; (26) Criorhina umbratilis Will.; *Lonchaeidae:* (27) Lonchaea polita Say—all s.

Lepidoptera—*Rhopalocera:* (28) Nisoniades juvenalis F., s.

Coleoptera—*Cerambycidae:* (29) Molorchus bimaculatus Say, s. & f. p.

CORNUS PANICULATA L'Her.—*C. candidissima* Marsh.—In his classification of floral types Delpino (3) places this species in his "Tipo idrangeino," which, as stated above, he regards as adapted to beetles. He considers the scent of the flowers, which he calls "odore carabico o scarabeo," as further indicating an adaptation to these insects. He saw the flowers abundantly visited by *Cetonia aurata* and other Coleoptera.

The shrubs are much branched, rise from 1 to 3^{m} high and bear numerous flat or convex cymes of white flowers. T cymes expand from 4 to 5^{cm}.

The four petals are horizontally expanded to the exte about 1^{cm}. The stigma rises to about the level of the anth Nectar is secreted by a yellow epigynous disk and is compl exposed.

The flowers are homogamous. Spontaneous self-pollina is usually prevented by the stamens being strongly diverge Insects crawl about over the clusters and become thoroug dusted with pollen. Pollination occurs between separate flowe of the same or distinct plants.

C. paniculata having completely exposed nectar is ada to a more miscellaneous set of insects than *C. florida*, which ha nectar more concealed. Nevertheless, the list of visitors of th former differs from that of the latter mainly in showing m insects of the same kind, it being a larger list. The list of *paniculata* shows twenty-one species of lower Aculeata and Tach inidae, only three of which are flying when *C. florida* is in bloo

The blooming season is May 12–June 13. The follow list was observed on May 12, 18, 23, 29, and June 8:

Hymenoptera—*Apidae:* (1) Apis mellifica L. ☿, s. & c. p., freq. Bombus americanorum F. ♀, c. p.; (3) Synhalonia frater Cr. ♀, c. p. Ceratina dupla Say ♀, s. & c. p.; *Andrenidae:* (5) Halictus pectoralis Sm. s. & c. p.; (6) H. pilosus Sm. ♀, s.; (7) H. confusus Sm. ♀, s. & c. p., fre (8) H. tegularis Rob. ♀, s., freq.; (9) H. stultus Cr. ♀, s. & c. p.; (10) Agap stemon radiatus Say ♀, s. & c. p.; (11) A. viridulus F. ♀, s. & c. p.; Augochlora confusa Rob. ♀, s. & c. p.; (13) A. similis Rob. ♀, s.; (14) Andre vicina Sm. ♀, s.; (15) A sayi Rob. ♀, s. & c. p.; (16) A. pruni Rob. (17) A. platyparia Rob. ♂ ♀, s. & c. p., ab.; (18) A. cressonii Rob. ♀, s. p.; (19) A. rugosa Rob. ♀, s. & c. p.; (20) A. forbesii Rob. ♀, s.; (21) hippotes Rob. ♀, s.; (22) A. claytoniae Rob. ♀, s. & c. p., freq.; (23) Pros pygmaea Cr. ♂, s.; (24) P. modesta Say ♂ ♀, s.; (25) P. affinis Sm. *Eumenidae:* (26) Eumenes fraternus Say; (27) Monobia 4-dens L. Odynerus sp.; (29) O. campestris Sauss.; (30) O. unifasciatus Sauss. O. foraminatus Sauss.; *Crabronidae:* (32) Crabro interruptus Lep., fre (33) C. errans Fox; (34) Oxybelus emarginatus Say; *Sphecidae:* (35) Pe poeus cementarius Dru.; (36) Chalybion caeruleum L.; *Pompilidae* Ceropales fulvipes Cr.; *Chalcididae:* (38) Smicra torvina Cr.—all s.

Diptera—*Empididae:* (39) Empis levicula Coq.; (40) E. clausa Coq.; E. distans Lw.; *Conopidae:* (42) Oncomyia loraria Lw.; *Syrphidae:* piza pulchella Will.; (44) Chrysogaster nitida F., freq.; (45) Syrphus canus Wd.; (46) Eristalis aeneus F.; (47) E. transversus Wd.; (48) E. diatus Wd.; (49) Mallota cimbiciformis Fll.; *Tachinidae:* (50) Alophora rascens Twns.; (51) Jurinia apicifera Wlk., freq.; (52) J. smaragdina ; (53) Belvosia bifasciata F.; (54) Phorocera edwardsii Will., freq.; (55) glossa hesperidarum Will.; (56) Frontina flavicauda Riley; (57) hopoda singularis Twns.; (58) Chaetophleps setosa Coq.; *Sarcophagidae:* (59) Sarcophaga sp.; (60) Helicobia helicis Twns.; *Muscidae:* (61) a sp.; (62) L. sericata Mg.; (63) Graphomyia americana R. D.; (64) eilia micans Mcq,; *Anthomyidae:* (65) Anthomyia marginata Wlk.; (66) rbia acra Wlk.; *Ortalidae:* (67) Camptoneura picta F.—all s.

Coleoptera—*Lampyridae:* (68) Podabrus tomentosus Say, freq.; (69) ephorus flavipes Lec., freq.; *Scarabaeidae:* (70) Euphoria fulgida F.; Trichius piger F., freq.; (72) T. affinis Gory, in cop.; *Cerambycidae:* Strangalia famelica Newm.; *Mordellidae:* (74) Pentaria trifasciata Melsh.; (75) Mordella marginata Melsh.—all s. or f. p.

Lepidoptera—*Rhopalocera:* (76) Pyrameis atalanta L.; (77) Papilio ajax L.—both s.

On the pollination of *Cornus* see:

(1) Sprengel, Das entdeckte Geheimniss 31, 33, 85. 1793. *C. mascula, nguinea, florida.*—(2) Axell, Om anordningarna för de fanerogama växternas kining 103. 1869. *C. Suecica.*—(3) Delpino, Ulteriori osservazioni II. 39, 46, 52, 215, 237-8, 311. Atti Soc. Ital. Sci. **16**: 161, 187, 194, 200. **17**: —. 1874. *C. florida, Suecica, paniculata, sanguinea.*—(4) Müller, fruchtung der Blumen 96. 1873. Fertilization of flowers 287. 1883. *C. nguinea.*—(5) Lubbock, British wild flowers in relation to insects 107. *C. Suecica, sanguinea.*—(6) Bonnier, Les nectaires. Ann. Sci. Nat. VI. **8**: 37, 40, 71, 135. 1878. *C. Mas, sanguinea.* (Just 7^1: 120).—(7) rera et Gevaert, Sur la structure et les modes de fécondation des fleurs. Soc. Bot. Belgique **17**: 79. 1878. *C. sanguinea.*—(8) Müller, Weitere achtungen **1**: 31. 1878. *C. sanguinea.*—(9) Patton, Observations on the Macropis. Am. Journ. Sci. & Arts III. **18**: 211-14. 1879. *C. paniculata.* (Just 7^1: 145).—(10) Jordan, Stellung der Honigbehälter und der fruchtungswerhzeuge in den Blumen 18. 1886. *C. sanguinea.*—(11) hner, Flora von Stuttgart und Umgabung 399. 1888. *C. sanguinea.*—(12) Schulz, Bestäubungseinreichtungen und Geschlechtsvertheilung bei den anzen **2**: 191. 1890. *C. Mas.*—(13) Kerner, Pflanzenleben **2**: —. 1891; ver translation **2**: 173, 183-4, 200, 231, 296, 289, 326. 1895. *C. florida, sanguinea, Suecica.*—(14) Meehan, Contributions to the life-histories of ants VIII. Proc. Acad. Sci. Phil. 1892: 376. *C. Canadensis, florida.* (Bot.

Centralb. **61**: 263).—(15) MacLeod, Bevruchting der bloemen van Vlaanderen. Bot. Jaarboek **6**: 256, 437. 1894. *C. sanguinea, Mas.*—(16) Loew. Blütenbiologische Floristik 248. 1894. *C. sanguinea, Mas.*

Viburnum pubescens Pursh.—The mode of pollination of this species, along with a general account of the genus and an index to the literature, has been given in Trans. Acad. Sci. St. Louis **7**: 170–2. The list of visitors recorded there, indicating a preponderance of beetles, is fragmentary and quite misleading. Beetles are more abundant on the old flowers, of which they eat all parts. The most frequent and efficient pollinators are the less specialized bees, and flies. The blooming season is May 2–25. The following list, observed on May 4, 5, 7 and 9, includes visitors previously mentioned. It shows an interesting assemblage of Empididae, a family of flies which reaches its maximum in May.

Bees—*Apidae:* (1) Bombus americanorum F. ♀, s.; (2) B. separatus Cr. ♀, s.; (3) Synhalonia frater Cr. ♂, s.; (4) Ceratina dupla Say ♀, s. & c. p.; (5) Osmia albiventris Cr. ♀, s.; *Andrenidae:* (6) Halictus pectoralis Sm. ♀, s. & c. p., freq.; (7) H. foxii Rob. ♀, s. & c. p.; (8) H. 4-maculatus Rob. ♀, s.; (9) H. coriaceus Sm. ♀, s.; (10) H. cressonii Rob. ♀, s. & c. p.; (11) H. confusus Sm. ♀, s. & c. p.; (12) Augochlora confusa Rob. ♀, s. & c. p.; (13) Andrena vicina Sm. ♀, s. & c. p.; (14) A. sayi Rob. ♀, s. & c. p., freq.; (15) A. robertson D. T. ♀, s. & c. p., freq.; (16) A. mandibularis Rob. ♀, s. & c. p., freq.; (17) A. illinoensis Rob. ♀, s.; (18) A. cressonii Rob. ♂ ♀, s. & c. p., ab.; (19) A. personata Rob. ♂, s. freq.; (20) A. nuda Rob. ♀, s. & c. p.; (21) A. rugosa Rob. ♀, s. & c. p., freq.; (22) A. forbesii Rob. ♀, s. & c. p.; (23) A. claytoniae Rob. ♀, s. & c. p., ab.; (24) Prosopis affinis Sm. ♂, s.; (25) P. modesta Say ♂, s.; (26) P. pygmaea Cr. ♀, s.

Diptera—*Conopidae:* (27) Myopa vesiculosa Say; *Empididae:* (28) Empis compta Coq.; (29) E. distans Lw., freq; (30) E. humilis Coq., freq.; (31) E. avida Coq.; (32) E. nuda Lw.; (33) E. levicula Coq.; (34) E. otiosa Coq.; (35) Pachymeria pudica Lw., freq.; (36) Rhamphomyia priapulus Lw., freq.; (37) R. exigua Lw.; (38) R. sordida Lw.; (39) R. angustipennis Lw.; (40) R. mutabilis Lw.; *Syrphidae:* (41) Chilosia capillata Lw.; (42) Mesograpta geminata Say; (43) Volucella vesiculosa F.; (44) Criorhina umbratilis Will., freq.; (45) C. decora Mcq.; (46) Xylota chalybea Wd.; (47) Syritta pipiens L.; *Tachinidae:* (48) Siphona illinoensis Twns., freq.; (49) Siphophyta floridensis Twns.; *Muscidae:* (50, 51) Lucilia spp.; *Oscinidae:* (52) Chloropa proxima Say; (53) Hippelates plebejus Lw.—all s.

Coleoptera—*Dermestidae:* (54) Anthrenus musaeorum L., freq.; (55)

yptorhopalum triste Lec.; (56) Orphilus glabratus F., ab.; *Lampyridae:* Telephorus dentiger Lec.; *Scarabaeidae:* (58) Hoplia trifasciata Say, s.; (59) Euphoria fulgida F.; (60) Valgus canaliculatus F., gn.; *Ceram- idae:* (61) Molorchus bimaculatus Say, s., ab.; (62) Callimoxys sanguini- lis Oliv.; (63) Euderces picipes F.; *Chrysomelidae:* (64) Diabrotica vittata s.; (65) Disonycha limbicollis Lec., s.; (66) Pachybrachys sp., s.; *Bru- idae:* (67) Bruchus hibisci Oliv., s.; *Oedemeridae:* (68) Asclera ruficollis Say, s.; *Mordellidae:* (69) Mordellistena biplagiata Hel., freq.; (70) M. aspersa Mels., freq.: (71) M. grammica Lec.—all s., f. p., or gn.

Lepidoptera — *Rhopalocera:* (72) Papilio ajax L.; (73) Nisoniades juvenalis F.—both s.

VIBURNUM PRUNIFOLIUM L.—This is a small tree bearing numerous flat compound cymes of white flowers. The corolla expands 8–9^{mm}, its base forming a short tube, which is somewhat obstructed by the short, thick style. The five stamens are strongly exserted, while the stigma is included in the tube. Nectar is secreted by a ring surrounding the base of the style. The flowers are homogamous. Cross-pollination by insects is assured, but self-pollination and geitonogamy may sometimes occur by the pollen falling upon the stigmas.

The blooming season is April 23–May 16. The following list was observed on April 24, 25, and 29:

Hymenoptera — *Apidae:* (1) Apis mellifica L. ☿, s. & c. p.; (2) Synhalonia frater Cr. ♂ ♀, s.; (3) Ceratina dupla Say, ♂, s.; (4) Osmia lignaria Say ♀, s.; (5) O. albiventris Cr. ♀, s.; (6) Nomada sayi Rob. ♂ ♀, s., freq.; N. cressonii Rob. ♂, s. freq.; (8) N. maculata Cr. ♂, s.; (9) N. obliterata Cr. ♂, s.; *Andrenidae:* (10) Halictus foxii Rob. ♀, s. & c. p.; (11) H. pectoralis Sm. ♀, s. & c. p. ab.; (12) H. lerouxii Lep. ♀ s. & c. p.; (13) H. cressonii Rob. ♀, s.; (14) H. pilosus Sm. ♀, s. & c. p.; (15) H. tegularis Rob. ♀, s. & c. p.; (16) H. confusus Sm. ♀, s. & c. p., ab.; (17) H. stultus Cr. ♀, s. & c. p., ab.; (18) Agapostemon radiatus Say, ♀, s.; (19) Augochlora confusa Rob. ♀, s. & c. p., freq.; (20) Sphecodes ranunculi Rob. ♀, s.; (21) S. dichrous Sm. ♀, s., freq.; (22) S. mandibularis Cr. ♀, s.; (23) S. stygius Rob. ♀, s.; (24) Andrena vicina Sm. ♀, s.; (25) A. pruni Rob. ♂ ♀, s. & c. p., in cop.; (26) A. sayi Rob. ♂ ♀, s. & c. p., freq.; (27) A. erythrogastra Ashm. ♂, s.; (28) A. cressonii Rob. ♂ ♀, s. & c. p., freq.; (29) A. bipunctata Cr. ♂ ♀, s. & c. p., ab.; (30) A. personata Rob. ♂ ♀, s., ab. (31) A. claytoniae Rob. ♀, s. & c. p; (32) A. forbesii Rob. ♀, s.; (33) A. hippotes Rob. ♀, s. & c. p.; (34) A. mariae Rob. ♀, s.: (35) Colletes inaequalis Say ♂; *Vespidae:* (36) Polistes metricus Say, s.; *Eumenidae:* (37) Odynerus tigris Sauss., s.

Diptera—*Stratiomyidae:* (38) Stratiomyia quaternaria Lw., s., freq.; *Empididae:* (39) Empis otiosa Coq., s., freq.; (40) Rhamphomyia priapulus Lw., s.; *Bombylidae:* (41) Bombylius major L., s.; (42) B. pulchellus Lw., s.; *Conopidae:* (43) Myopa vesiculosa Say, s., freq., in cop.; *Syrphidae:* (44) Paragus bicolor F.; (45) Psilota buccata Mcq.; (46) Chrysogaster pictipennis Will.; (47) Chilosia sp.; (48) C. capillata, Lw., freq.; (49) C. versipellis Will., freq.; (50) Mesograpta marginata Say; (51) M. geminata Say; (52) Myiolepta strigillata Lw., freq.; (53) Brachyopa vacua O. S.; (54) Eristalis aeneus F., freq.; (55) E. dimidiatus Wd.; (56) E. transversus Wd.; (57) Helophilus latifrons Lw.; (58) Criorhina umbratilis Will.; (59) C. decora Mcq.; (60) Syritta pipiens L.; *Tachinidae:* (61) Gymnosoma fulginosa R. D.; (62) Jurinia apicifera Wlk.; (63) Peleteria robusta Wd., freq.; (64) Gonia frontosa Say; *Muscidae:* (65) Graphomyia americana R. D.; (66) Lucilia sp.; (67) L. caesar L.; (68) L. cornicina F.; (69) L. latifrons Schin., freq.—all s. or f. p.

Lepidoptera—*Rhopalocera:* (70) Pyrameis huntera F.; (71) Phyciodes nycteis Db.-Hew.; (72) Thecla melinus Hbn.; (73) Lycaena pseudargiolus Bd.-Lec.; (74) Nysoniades juvenalis F., freq.; (75) N. martialis Scud.; *Sphingidae:* (76) Hemaris thysbe F.—all s.

LONICERA L.—The flowers of honeysuckles present quite a variety of forms and adaptations. In the case of zygomorphous flowers in general, except those like Heracleum, I have advanced the proposition[1] that the flowers were originally adapted to bees, or principally visited by them. Correlated with this is the proposition that hawk moths and humming birds, from the fact that they do not alight upon the flower, do not have any influence in producing irregularity, and that the irregular flowers which are adapted to them were monopolized by them after they had been changed to an irregular form by bees. I assume that the flowers have become sternotribe from the fact that bees have been in the habit of landing upon the stamens and style. While the hawk moths do not tend to produce irregular flowers, it does not follow that their influence is to turn such flowers back to a more regular form, for the limitation of the pollen contact to the undersides of their bodies is clearly advantageous to the flowers. I suppose then, that the irregular sphingophilous species were originally bumble-bee flowers which have been usurped and further modified by hawk moths. The bumble-bee flowers may have come from the short-tube forms, which were adapted to the less specialized bees or to wasps. Or, the wasp-flowers may have come from those adapted to bumble-bees by a process of retrograde metamorphosis, as in the case of Scrophularia. If the bird-flower, *L. sempervirens*, came from an irregular form, I do not understand how it has lost it. However, the more regular form has the effect of lengthening the tube and of excluding the intruders which might remove the pollen.

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[1] Zygomorphy and its causes. BOT. GAZ. 13: 229. 1888.

The irregular flowers have four lobes above forming a vexillum—one of the many cases Henslow's theory will not account for—and a single lobe below, which projects forwards and assists in supporting the visitor, or is reflexed.

The flowers of most species are more or less horizontal, and this is the typical position, if my theory is correct. Some are nearly erect and others pendulous.

The corolla tube varies in length from 7^{cm} in *L. longiflora* (Delpino 7) to $3–4^{mm}$ in *L. xylosteum* (Müller 5). The long-tubed species are adapted to hawk moths, those of mid-length to bumble-bees, while the short-tubed species are adapted to the smaller bees, or even in one case to wasps, as *L. alpigena* (Müller 14). The last case is questioned by Schulz (29). MacLeod and others have been so confused by observing the frequent visits of bees to wasp-flowers that they have been inclined to abandon that category. But the wasp-flowers always show a proportion of wasps that is not equaled in any other flowers.

The usual color appears to be yellowish, the old flowers inclining to turn purplish, or white with rosy or purplish tints. The sphingophilous species are commonly whitish, the ornithophilous *L. sempervirens* red, as in all of our bird-flowers—*Tecoma radicans*, *Aquilegia Canadensis*, *Lobelia cardinalis*, *Castilleia coccinea*—while *L. alpigena* is reddish brown, as in Scrophularia.

The sphingophilous species open at night and emit a strong scent at that time, but the ornithophilous *L. sempervirens* is said by Hancock[2] (34) to be scentless.

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[2] This author has a good deal to say about certain wonderful pollen-holding structures on the head of *Trochilus colubris*. Unfortunately, they are in the wrong

According to Kerner (31), in the twining honeysuckles (*L. caprifolium*, *etrusca*, *grata*, *implexa*, *periclymenum*, etc.) nectar is secreted in the lowest part of the tube, while in the non-twining ones (*L. alpigena*, *nigra*, *xylosteum*, etc.) it is secreted in an expansion above the base. In the sphingophilous species the nectar is protected from unbidden guests by the long, narrow tube; in the shorter, wider tubed species it is protected by hairs upon the filaments and the inner wall of the corolla. Under conditions unfavorable for the visits of hawk moths, nectar accumulates in the long-tubed species until a part of it becomes accessible to some long-tongued intruders.

Some observers have found in the tubes holes which, they imagined, were made by bees. Müller saw *L. coerulea* perforated by *Bombus mastrucatus*. Schneck (27) saw *Megachile brevis* cutting circular pieces out of the tubes of *L. sempervirens*, as he says, to obtain the nectar. I have seen this bee cut such pieces out of the corollas of *Œnothera fruticosa*, *Cassia Chamaecrista* and *Ruellia ciliosa*, but she carried them away to use in her nests.

The anthers are exposed so that the pollen is accessible to a number of intruders, principally *Andrenidae* and *Syrphidae*, which may collect it or feed upon it, usually doing harm, though they may sometimes effect cross- or self-pollination. Meehan (22, etc.,), who has observed only this kind of insect visits to a cultivated exotic species, concludes from it that the presence of nectar is of no significance as an adaptation for insect pollination.

The statements in regard to dichogamy, or other adaptations for cross-pollination, are remarkably conflicting. *L. caprifolium* is homogamous according to Müller (5), slightly proterogynous according to Kirchner (28). *L. xylosteum* is homogamous (Müller) and proterogynous with spontaneous alternating movements of stamens and style (Kerner). *L. coerulea* is proterogynous (Hildebrand 2, Ricca 4) and homogamous (Müller 1). Müller calls *L. periclymenum* homogamous, and supposes that cross-pollination is favored by the stigma being in advance of

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place, for all of our bird-flowers whose ranges approach that of the ruby-throat, will, with the exception of *A. Canadensis*, strike the bird on the upper side. The case is imaginary, anyhow.

the anthers; Knuth (38) shows that, as a result of the correlated movements of the style and stamens, the anthers are exposed in the way of the visitor on the first evening and the stigma on the second. *L. alpigena* is homogamous (Müller) and proterogynous (Kerner). In one place Meehan says *L. Japonica* is proterogynous (23), in another homogamous (36). *L. nigra* and *Tatarica* are homogamous (Müller). *L. Iberica* is slightly proterogynous (Kirchner 28). The common woodbine (?) and *L. sempervirens* are proterandrous (Schneck 27). In *L. alpigena, nigra*, etc., according to Kerner, there occurs a change of position of the stamens and stigma by which they are placed in the way of the visitors at different times, probably as in *L. periclymenum.*

	Sphingidae	Other Lepidoptera	Bombus	Other bees	Wasps	Diptera	Other insects	Trochilus
PHINGOPHILOUS.								
caprifolium, Germany, Müller	6	4						
Flanders, MacLeod	1							
periclymenum, Germany, Müller	6		1					
Northfrissian Islands, Knuth	5	1	2		1	7		
Flanders, MacLeod	1		2					
———, White		×						
Scotland, Willis			1					
Holland, Heinsius			1					
aponica ———, Meehan				1				
MBUS-FLOWERS.								
oerulea, Alps, Müller	1	2	6	8	3	3	2	
Alps, Ricca			1					
ylosteum, Germany, Müller,			2	1		2		
Alps, Ricca			×	×		×		
berica, Hohenheim Bot. G., Kirchner			1	1				
ullivantii, Illinois			2	1		1		1
ELITTOPHILOUS.								
atarica, Germany, Müller				3		1		
Northfrissian Islands, Knuth						1		
igra, Alps, Müller				2				
ASP-FLOWERS.								
lpigena, Alps, Müller	1	1	3	4	2	2		
Tyrol, Schulz	2		×	×	4	×		
RNITHOPHILOUS.								
empervirens, Illinois								1

The preceding table gives the insect visitors of *Lonicera* as observed in different regions.

Lonicera Sullivantii Gray.—This honeysuckle occurs in two places in my neighborhood, on creek banks. The flowers are in clusters at the ends of the branches and hold a more or less horizontal position. Newly opened ones are rather pale yellow, but later show a purplish tinge. The upper lip consists of four lobes which are turned up like a vexillum; the lower consists of a single lobe. Bees land upon the stamens and style, which are exserted about 7^{mm}. The corolla tube measures $14–18^{mm}$ in length. Nectar is secreted and retained in a slight gibbosity near the base of the tube.

The flowers are homogamous, the stigmas are receptive a little before the opening of the anthers, but the proterogyny is too slight to be of much importance. The stigma is somewhat in advance of the anthers, but not enough always to prevent spontaneous self-pollination.

I have observed flowers opening as early as 4 o'clock in the afternoon, the anthers beginning to open at 5:15 o'clock, and most of the flowers shedding pollen by 5:30. These flowers were visited by *Bombus virginicus* Oliv. ♀, three; *Anthophora ursina* Cr. ♀ and the humming bird, *Trochilus colubris* L., so that there was abundant opportunity for them to be effectually pollinated before sundown. The work of pollination may be completed by hawk moths in the evening, or when the bees and humming birds return next morning.

The blooming season is short; May 15–June 6. I have seen the flowers visited in the morning by:

Bees: (1) Bombus virginicus Oliv. ♀, s., freq.; (2) B. americanorum F., s.; (3) Anthophora ursina Cr. ♀, s. & c. p., freq.

Birds: (4) Trochilus colubris L., s., freq.

Flies—*Syrphidae*: (5) Pipiza femoralis Lw., f. p., one.

On the pollination of Lonicera see:

(1) Sprengel, Das entdeckte Geheimniss 120. 1793. *L. xylosteum, caprifolium.*—(2) Hildebrand, Geschlechter-vertheilung bei den Pflanzen 18. 1867. *L. coerulea.*—(3) Axell, Om anordningarna för de fanerogama väx-

mas befruchtning 37, 64–5, 98. 1869. *L. coerulea.*—(4) Ricca, Osserva-
sulla fecondazione incrociata dei vegetali alpini e subalpini. Atti Soc.
al. Sci. **14**:255–6. 1871. *L. nigra, xylosteum, coerulea.*—(5) Müller,
efruchtung der Blumen 361–4. 1873. *L. periclymenum, caprifolium, tatarica,*
losteum.—(6) White, The influence of insect agency on the distribution
plants. Am. Nat. **7**:271. 1873. *L. periclymenum.* (Just **1**:377.)—(7)
elpino. Ulteriori osservazioni II. **2**:44, 114, 179, 276, 336; Atti Soc. Ital.
16:192, 262, 327. 1873; **17**:—. 1874. *L. caprifolium, coerulea, xylos-*
teum, periclymenum, longiflora, sempervirens. (Just **2**:893.)—(8) Lubbock,
itish wild flowers in relation to insects 108–10. 1875. *L. caprifolium,*
riclymenum, xylosteum.—(9) Gray, Darwin on the effects of cross and self-
ertilization in the vegetable kingdom. Am. Journ. Sci. & Arts III. **13**:133.
(Just **5**^{1}:743.)—(10) Bonnier, Les Nectaires. Ann. Sci. Nat. Bot. VI.
86, 138–9, 187, 192. 1878. *L. fragrantissima, periclymenum, semper-*
rens, standeskii.—(11) Errera et Gevaert, Sur la structure et les modes de
ndation des fleurs. Bull. Soc. Bot. Belgique **17**:106. 1878. *L. capri-*
lium.—(12) Dodel-Port, Die Liebe der Blumen. Illustr. Pflanzenleben
ef. 4 5:185–240. 1880. *L. periclymenum.* (Just **8**^{1}:183.)—(13) Gray,
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HELIANTHUS DIVARICATUS L.—The following visitors were observed on August 8, 14, 17, 21, 24, 27, 29, 31, and September 2, 4, 7, and 10:

Bees—*Apidae:* (1) Bombus americanorum F. ♀, s.; (2) B. scutellaris ☿, s. & c. p.; (3) B. separatus Cr. ♀, s.; (4) Melissodes obliqua Say ♂ ♀, s. & c. p., freq.; (5) M. coloradensis Cr. ♂ ♀, s. & c. p., freq.; (6) M. americana Lep. ♂ ♀, s. & c. p., freq.; (7) M. nivea Rob. ♂, s., freq.; (8) M. pennsylvanica Lep. ♀, s. & c. p.; (9) M. simillima Rob. ♂, s.; (10) M. aurigenia Cr. ♂, s.; (11) Megachile mendica Cr. ♂, s.; (12) M. optiva Cr. ♀, s.; (13) Coelioxys totonaca Cr. ♀, s.; (14) C. 8-dentata Say ♂, s.; (15) C. sayi Rob. ♂, s.; (16) Epeolus concavus Cr. ♀, s.; (17) E. lunatus Say ♀, s.; (18) E. donatus Sm. ♂ ♀, s., freq.; (19) E. compactus Cr. ♂, s., freq.; (20) E. pusillus Cr. ♂, s.; (21) E. nevadensis Cr. ♀, s.; (22) E. cressonii Rob. ♂ ♀, s.; (23) Panurginus labrosiformis Rob. ♀, s. & c. p.; (24) P. rugosus Rob. ♀, s. & c. p.; (25) Halictoides marginatus Cr. ♂ ♀, s. & c. p., freq.; *Andrenidae:* (26) Halictus pectoralis Sm. ♂ ♀, s. & c. p., freq.; (27) H. ligatus Say ♂ ♀, s. & c. p., freq.; (28) Augochlora confusa

Rob. ♂ ♀, s. & c. p.; (29) Colletes americanus Cr. ♂ ♀, s.; (30) Andrena helianthi Rob. ♂, s.; (31) A. pulchella Rob. ♀, s. & c. p.

Diptera—*Bombylidae:* (32) Exoprosopa decora Lw.; (33) Anthrax palli- ata Lw.; (34) A. halcyon Say; (35) Sparnopolius fulvus Wd., ab.; (36) stoechus vulgaris Lw.; *Conopidae:* (37) Zodion fulvifrons Say, freq.; (38) nanellum Lw.; *Syrphidae:* (39) Eristalis transversus Wd.; *Anthomyidae:* (40) Proboscimyia siphonina Bigot—all s.

Lepidoptera—*Rhopalocera:* (41) Phyciodes nycteis Db.-Hew.; (42) Catopsilia eubule L.; (43) Colias philodice Gdt.; (44) Pamphila cernes Edw.—all s.

Blackburn College,
Carlinville, Ill.

PYROLA APHYLLA: A MORPHOLOGICAL STUDY.

THEO. HOLM.

(WITH PLATE XVII)

It would seem very strange if there really existed a truly leafless species in a genus like Pyrola, of which all the other representatives are not only leafy, but even evergreen. One might think at a first glance that the lack of proper leaves would influence the species so much in its mode of growth, as a saprophyte or parasite, as to warrant its segregation from the genus Pyrola. Entire genera devoid of proper leaves are not so very scarce in the phanerogams, but in no case does there exist a genus which contains autophytic, saprophytic, and parasitic species. There are several families, on the other hand, in which we meet with both leafy and leafless genera; for instance, the apparently leafless Epirhizanthes among the Polygalaceæ; Voyria and Voyriella among the Gentianaceæ; Monotropa, Sarcodes, Pterospora, etc., among the Pyrolaceæ; Neottia, Corallorhiza, etc., among the Orchidaceæ; and, finally, Baillon's remarkable Geosiris among the Iridaceæ.[1] These instances are familiar to us, but we are unable to cite any genus which has both autophytic and parasitic species, with the exception, as it has been believed, of Pyrola. The fact is, however, that, notwithstanding statements made by such prominent authors as DeCandolle and Hooker, the plant is not by any means aphyllous, but has evidently received its name for the same reason that Galax was named *aphylla* by Linnæus, the original specimens having but imperfectly represented the species. Thus has DeCandolle described our Pyrola as "foliis veris nullis" and as a "species absentia foliorum spectabilis et quasi ad Monotropeas vergens," while Hooker goes still further in stating "folia omnino nulla."

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[1] For references consult the bibliography appended to this article.

The figure in Hooker's work shows distinctly that his specimen was but fragmentary. Nuttall, shortly after Hooker, corrected this mistake by stating "occasionally it produces, near the root and on infertile shoots, a few small, ovate, or lanceolate greenish leaves." It is very surprising that Gray in later years should still have described it as "leafless, doubtless parasitic," and as a peculiarly interesting plant on account of its living the parasitic life of the Monotropeæ." To Nuttall, therefore, belongs the credit of having discovered the leaves of this singular plant which Smith at first described as destitute of leaves, and accordingly named it "leafless wintergreen." These contradictory statements, however, have led the writer to investigate the matter fully, after having secured some excellent living specimens from Amador county, California, which were kindly collected by Mr. Geo. Hansen. Besides confirming Nuttall's observations of the presence of proper leaves, I have detected a few peculiarities which will be presented in this paper.

The accompanying *fig. 1* represents a mature and very carefully collected specimen of our plant, and we notice here several underground shoots, of which one bears a rosette of leaves at its apex (*L*), in the same manner as in other species of Pyrola. In considering the leaves by themselves, they are, as described by Nuttall, rather small, but provided with a distinct petiole and a blade, varying from lanceolate to broadly ovate, obtuse, or slightly pointed (*figs. 2, 3*). These leaves were green, and the chlorophyll became still more conspicuous by immersing the leaves in strong alcohol, which readily assumed a deep green color, which afterwards turned dark brown from the large content of tannin in the cell sap. As regards the minute structure of these leaves, we did not observe any peculiarity by which our species might be separated from the other species of Pyrola, and there is absolutely no character whatever that might warrant the supposition that our plant lives a saprophytic or a parasitic life. The epidermis is perfectly normal and covered by a thick and wrinkled cuticle, common to evergreen leaves; stomata are present on both faces of the blade, but are most numerous on the lower surface; no hairs or glands were observed on either face. The chlorophyll-bearing tissue is differentiated into a palisade tissue of about two layers on the ventral face of the blade, and an ordinary pneumatic tissue, the cells of which are roundish and loosely connected with each other, leaving intercellular spaces of quite considerable width. The mestome bundles possess all the elements as found in other dicotyledons, and are supported by a collenchymatic tissue which makes the nerves very prominent on the lower surface of the leaf.

Besides these completely developed leaves, our plant possesses also scale-like ones, which are much more numerous, covering not only the underground shoots, but also the base of the inflorescences (i^1 and i^2 in *fig. 1*). Very characteristic of *Pyrola aphylla* is the profuse development of axillary buds, which are readily observed upon the underground stems and at the base of the aerial floral and vegetative shoots. These axillary buds, however, are restricted to the scale-like leaves, since I failed to detect any such in the axils of those provided with petiole and blade. The first two leaves of such axillary buds are situated to the right and left of the diminutive bud axis, while the third and fourth appear almost in regular alternation with these, those following, on the contrary, forming an ordinary spiral.

Upon examining the stem underground we notice in our figure (*fig. 1*) two long branches (b^1 and b^2) with elongated internodes, which show an ascending curvature from the root, from which point they creep horizontally underneath the surface of the soil, until they finally push up through it, either terminated at once by the inflorescence or first by a rosette of proper leaves. It is easily understood that it has been the collecting of just such underground branches, terminated by inflorescences and not preceded by a rosette of leaves, which has misled botanists to consider our plant as aphyllous and parasitic. The anatomical structure of these underground branches, which constitute the rhizome of *Pyrola aphylla*, is, however, that of a true autophyte showing the well-known elements of normally developed tissues. There is a wrinkled cuticle covering the thick-walled epidermis, inside of which follows a heavy layer of cork parenchyma of rather closely packed polyhedric cells, which border on a thin-walled endodermis. This endodermis encircles the leptome and hadrome, the last of which has distinctly lignified cell walls, while an ordinary pith occupies the innermost part of the central cylinder. Tannin was observed in abundance in the cells of the bark and epidermis.

In comparing the structure with that of the aerial flower-bearing stem, we notice only a few divergencies. The bark contains chlorophyll, and a closed ring of stereome is developed around the central cylinder, of which the pith occupies the larger part. In combining these anatomical features of the leaves, the aerial and subterranean stem, there is so far no indication of our plant being a parasite or saprophyte or in any other way differing from the other species of Pyrola.

The last organ of the plant, which is not to be overlooked, is the root, the main and the adventitious. Only a part of the main root was preserved in our specimens (*R* in *fig. 1*), and it is by no means certain whether this dark colored and slightly branched root is the main root or merely a branch. It is from this root, however, that the subterranean shoots have developed as true root-shoots, a fact that is readily observed in *fig. 1*. We not only observe that the two long underground branches proceed directly from this root, but also the development of two dense clusters of shoots with more or less curved apices, all of which are beginning to develop into underground creeping stems, like the two larger ones described above (b^1 and b^2). Our plant shows then a strongly pronounced vegetative propagation, which perhaps has reached a higher development in this than in any other species of Pyrola. Adventitious roots were also observed. They are rather thin and show only a few ramifications. Their position is somewhat peculiar, since they break out a short distance above the scale-like leaves, and either to the right or left of the axillary buds.

Besides the fact that we have not been able to detect any haustoria upon the roots, the interior structure is sufficient to show the nature of our plant, whether it is an autophyte, a parasite, or a saprophyte. The presence of green leaves, however, is sufficient to determine the question whether the plant is a saprophyte, and a general consideration of the anatomy of the roots will suffice to convince any observer that *Pyrola aphylla* is no parasite either. Root-hairs are developed from the epidermis, inside of which there is a hypoderm of rather large cells, which surrounds a bark-parenchyma of normal structure and packed with starch, but without any trace of fungal mycelia. The endodermis is perfectly normal and surrounds, together with the pericambium, the five groups of leptome, alternating with a corresponding number of hadrome groups, while the innermost part of the central cylinder is occupied by a few strata of conjunctive tissue.

Pyrola aphylla shows, therefore, a striking ability to propagate by means of axillary buds developed upon the underground stems, and likewise by adventitious buds which push out very freely from the roots. Propagation by seeds is not excluded, and each capsule contains a large number of very minute, but mature seeds. By bringing these facts together with the anatomical structure of the vegetative organs, it may be seen that our plant shows no sign of living a parasitic life or even a saprophytic one, but that it is a true autophyte. This becomes the more evident when we compare our species with its nearest relatives, of the genus Pyrola itself, of Moneses and Chimaphila.

From the writings of Irmisch we have learned that a similar reproduction by root-shoots takes place in *Pyrola secunda*, *P. chlorantha*, and in *Moneses uniflora*. Besides, we have succeeded in finding similar shoots from the roots of *Pyrola picta*, *Chimaphila umbellata*, and *C. maculata*. The morphological characters of the vegetative organs of the species of Pyrola depend especially upon the development of the proper leaves, whether they precede or are contemporary with the flowers. According to Irmisch, some of the leaves develop in the same year as the flowers in *Pyrola minor*, while in *P. secunda* and *P. rotundifolia* all the proper leaves have appeared during the year previous to the flowering. It is to be noted that a few rudimentary scale-like leaves occur also in these species, preceding and succeeding the proper ones. While the inflorescence is strictly terminal in the above mentioned species of Pyrola, Irmisch observed also lateral ones in *P. chlorantha*, and it is interesting to notice that these lateral inflorescences possessed only undeveloped leaves at their bases.

In our plant, *Pyrola aphylla*, we have both terminal and lateral inflorescences, the terminal being, perhaps, constantly preceded by normal leaves (*L* in *fig. 1*), which appeared during the year previous to the flowering, agreeing in this respect with *P. secunda*, *P. chlorantha*, and *P. rotundifolia*. No axillary buds were observed in the axils of the green leaves, a fact that furnishes another illustration of the great resemblance which exists in the vegetative organs of Pyrola. The most conspicuous character of *P. aphylla*, if we merely compare the vegetative organs, lies in the scanty foliage of proper leaves, which, however, has become in part replaced by an unusually large number of scale-like ones.

If we compare our plant with Chimaphila, of which we have examined *C. umbellata* and *C. maculata*, we shall find many analogies. We have already stated that we observed root-shoots in both of these species, and *fig. 4* shows the base of an old plant of *C. maculata*, with a young shoot pushing out from one of the lateral roots (*R. S.*). The species of Chimaphila also develop long horizontally creeping and branching rhizomes, which in a specimen of *C. umbellata* reached a length of two-thirds of a meter. The aerial shoots of Chimaphila differ, however, from those of *Pyrola aphylla* and the other species mentioned above, in that the proper leaves support buds, which develop during the following year.

In respect to the absence of scale-like leaves at the base of the inflorescence and above the proper leaves, Chimaphila agrees with several of the species of Pyrola, but not with *P. minor* and

P. aphylla. It seems, on the whole, that these members of the Pyrolaceæ, Pyrola, Moneses, and Chimaphila, form a very natural group by themselves, if we consider their morphological characters, and their floral and vegetative structures. While *Pyrola secunda*, *P. aphylla*, *P. picta*, and *P. chlorantha* are the only species which have been observed to produce root-shoots, we should not feel surprised if this be the case also with all the other species, as in Moneses and Chimaphila. But we doubt very much whether any of these genera live as true saprophytes, although the supposed related Monotropeæ are known to live as such.

There is yet another point of interest in the life history of the Pyrolaceæ which we should like to touch upon, even though it may seem somewhat foreign to the main subject of this paper. The germination of the Pyrolaceæ is almost unknown, and with the exception of *Pyrola secunda* and Monotropa, none have been examined at this early stage of development. In his description of the germination of *P. secunda*, Irmisch points out the lack of two opposite cotyledons, while a series of about ten scale-like leaves, all underground, precede the proper ones. These rudimentary leaves were pale, and they were situated at some distance from each other upon the underground part of the stem. Buds were observed in the axils of these leaves, and some of them had already pushed out so as to form ascending shoots. Secondary roots were seen in several cases to break out above a number of these buds. This manner of germinating, with no proper cotyledons, is rather rare among the dicotyledons, but is especially characteristic of the parasitic forms, Orobancheæ (excepting Lathræa), Balanophoreæ, Cuscuta, etc., besides the saprophytic genus Monotropa. It seems very strange that *Pyrola secunda* should exhibit a similar manner of germination, since it does not otherwise behave as a saprophyte. It is the more surprising, also, in view of the fact that *Chimaphila maculata* germinates in the same way as the majority of the other dicotyledons. We succeeded in finding a number of seedlings of this species in the month of July, while we were digging out some mature specimens for the purpose of examining the rhizomes. These seedlings, one of which is figured (*fig. 5*), showed then a long hypocotyl (*H* in the figure), two normal green cotyledons (*Cot.*) which were almost sessile, the blade oblong or approximately obovate. The first two leaves, succeeding the cotyledons, had a distinct petiole and an oblong blade, while the third showed the first traces of dentation and represented a tridentate leaf. The main root (*R*) was long, slightly branched, and covered with root-hairs; one pair of secondary roots (*r*) were developed just above the main one, but in no other place were such secondary roots observed upon these minute seedlings. Although *Chimaphila umbellata* is not uncommon in the vicinity of Washington, we have not yet been able to detect its seedlings, but it is not likely that they differ from those of *C. maculata*, as the manner of growth of these species is exactly the same. The species of Pyrola and Moneses demonstrate, on the contrary, a somewhat different mode of growth, which perhaps may be visible at the earliest stages of their development during germination.

WASHINGTON, D. C.

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EXPLANATION OF PLATE XVII.

FIG. 1. A mature specimen of *Pyrola aphylla*. A rosette of is to be seen at *L*; the base of two inflorescences at i^1 and i^2; the underground branches, which have developed from the root with two clusters of small, ascending shoots. Natural size.

FIGS. 2 and 3. Leaves from the rosette. ×2.

FIG. 4. Rhizome of *Chimaphila maculata*, showing the base of stems (s^1 and s^2) with underground lateral shoots; a small root- be seen at *R. S.* ×2.

FIG. 5. Seedling of *Chimaphila maculata*. R = the primar and r = the first pair of secondary roots; H = the hypocotyl; cotyledons. ×3.

S^1
S^2
R.S.
4.
L
b^1
i^2
b^2
2.
3.
R
1.
R.

HOLM on PYROLA APHYLLA.

Autor ad nat. del.

NOTES ON THE SALT MARSH PLANTS OF NORTHERN KANSAS.[1]

JOHN H. SCHAFFNER.

All through the central part of Kansas salt marshes and salt springs are quite common, and small salt licks are found in most parts of the state. Perhaps the largest of these marshes is the Big marsh, which stretches along Big Marsh creek from the northwest part of Cloud county through the southwest corner of Republic county, and for several miles into Jewell county. The writer visited this marsh in August 1897 in order to study the vegetation of the region. It is about seven miles long, and varies from a quarter to a mile in width. The marsh proper is a malodorous black bog, and large stretches are absolutely without vegetation. In the lower part of the marsh, in Cloud county, where the main observations were made, it is over a mile wide and there are places where one may walk for half a mile without finding a shoot of any kind. The salt, at a distance, looks like a light covering of snow. Although the weather had been very dry for a long time before my visit, a small stream of water was flowing through the shallow bed of the creek, and the surface of the marsh was quite moist and even muddy in places, being springy under foot. A beautiful mirage appeared in the distance over the marsh, which looked like a most inviting lake of pure water with green patches of vegetation. So complete was the resemblance that it was very difficult to believe that the phantom lake was not real water.

In Big marsh the conditions are still quite natural, large areas having never yet been fenced. However, it is said that the saline area has diminished much since the settlement of the country. The most striking feature is the utter barrenness of the district when compared with the surrounding country, and the absence of belts of trees and shrubs along the banks of the creek. The only woody plant seen growing on the outside of the marsh was *Amorpha fruticosa* L. Along the stream which flows through the marsh there are here and there patches of deposits somewhat raised above the general level and rather free from salt. These contain some plants which could not otherwise grow in the marsh. There are also sedges growing along the stream and its muddy bottom is covered with a brown deposit of diatoms. The greater part of the marsh proper is entirely barren, but in some places there are isolated patches of salt marsh plants. On the outer portion beyond the barren area there are often well marked zones of vegetation, especially where the ground rises gently from the marsh. Here the zones are very distinct, while in other places they may be crowded close together, and some zones may be omitted entirely.

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[1] Contributions from the botanical laboratory of Ohio State University. I.

The three sedges which grow in and along the stream are *Scirpus pungens* Vahl., *S. campestris* Britton, and *S. lacustris* L.

In the higher patches of alluvial deposit along the stream the following plants were collected: *Distichlis maritima* Raf., *Panicum Crus-galli* L., *Elymus Virginicus* L., *Spartina cynosuroides* Willd., *Rumex Britannica* L., *Polygonum Hydropiper* L., *P. Persicaria* L., *P. ramosissimum* Michx., *Amarantus chlorostachys* Willd., *Iva ciliata* Willd.

In the barren portion away from the stream, where the ground is a little higher and less salty, there were patches of *Polygonum ramosissimum* Michx. and *Distichlis maritima* Raf. Very often both these plants were growing together, the Polygonum usually occupying the center, and the Distichlis forming a border around it.

On the outer margin of the barren area, where there was a gentle rise of the ground from the marsh outward, the following seven zones were determined.

FIRST ZONE: A few yards wide and composed entirely of *Distichlis maritima* Raf. On the inner side the grass was evidently having a hard struggle for a meager existence, and was mostly dead.

SECOND ZONE: A narrow strip a few yards wide composed of *Distichlis maritima* Raf., *Polygonum ramosissimum* Michx., and *Suæda diffusa* Watson. The Polygonum grows vigorously and forms the characteristic plant. This zone seems to be just above the outer limit of the ordinary inundations of the salt brine. Distichlis was abundant, but Suæda was only thinly interspersed, and there were many dead and dry specimens.

THIRD ZONE: This is a wide dry zone, with the following plants: *Distichlis maritima* Raf., characteristic and rather stunted in its growth; *Polygonum ramosissimum* Michx., quite rare, probably because of dryness; *Suæda diffusa* Watson, interspersed, quite common; *Iva ciliata* Willd., rare.

FOURTH ZONE: Usually about as wide as the last, and with the following plants: *Distichlis maritima* Raf., characteristic; *Polygonum ramosissimum* Michx., not very common; *Suæda diffusa* Watson, occasional; *Iva ciliata* Willd., not very common; *Sporobolus heterolepis* Gray, characteristic; *S. Texanus* Vasey, abundant in some places; *Atriplex expansa* Watson, rare; *Aster multiflorus* Ait., occasional.

FIFTH ZONE: A rather wide zone in which plants less characteristic of halophyte regions are trying to gain a foothold. *Iva ciliata* Willd. is the prominent plant of this zone. The following plants were collected: *Distichlis maritima* Raf., abundant; *Polygonum ramosissimum* Michx., not common; *Iva ciliata* Willd., characteristic; *Sporobolus heterolepis* Gray, common; *Sporobolus Texanus* Vasey, in some places; *Atriplex expansa* Watson, occasional; *Aster multiflorus* Ait., occasional; *Scirpus pungens* Vahl., common; *Hordeum jubatum* L., occasional; *Panicum virgatum* L., sometimes in patches; *Gaura parviflora* Dougl., occasional; *Ambrosia psilostachya* DC., rare.

SIXTH ZONE: The outer margin of the salt marsh proper, usually accompanied by a rise in the ground. Much like the last zone except that here *Ambrosia psilostachya* DC. is abundant, and gives the character instead of *Iva ciliata* Willd. The following plants were collected: *Distichlis maritima* Raf., *Polygonum*

ramosissimum Michx., *Iva ciliata* Willd., *Sporobolus heterolepis* Gray, *Hordeum jubatum* L., *Scirpus pungens* Vahl., *Panicum virgatum* L., *Gaura parviflora* Dougl., *Ambrosia psilostachya* DC. (abundant), *Glycyrrhiza lepidota* Nutt.

Seventh zone: The transition zone on the outer margin of the salt marsh proper where, beside occasional representatives of most of the plants found in the inner zones, the following plants are present: *Iva ciliata* Willd., *Sporobolus heterolepis* Gray, *Panicum virgatum* L., *Gaura parviflora* Dougl., *Ambrosia psilostachya* DC., *Glycyrrhiza lepidota* Nutt., *Aster multiflorus* Ait., *Helianthus annuus* L., *Erigeron Canadensis* L., *Xanthium strumarium* L., *Grindelia squarrosa* Dunal, *Desmanthus brachylobus* Benth., *Amorpha fruticosa* L., *Œnothera biennis* L., *Physalis lanceolata* Michx., *Euphorbia glyptosperma* Engelm., *Euphorbia marginata* Pursh, *Amarantus blitoides* Watson, *Elymus Virginicus* L., *Spartina cynosuroides* Willd., *Scirpus pungens* Vahl.

THE SEAPO, OR TUTHILL'S MARSH.

About eighteen miles east, and a little north of Big marsh in the southeast part of Republic county, there is a salt marsh on Little Marsh creek, which is commonly called Tuthill's marsh. This was visited the last of August 1897. It has suffered much from the cultivated soil on the high ground around it. Its margin is very irregular, both as to surface and vegetation. At present it is fenced and in pasture, and, although there are several hundred acres still without vegetation, it is much smaller than formerly and natural conditions are much disturbed. There are many irregular barren spots along the border, and no well marked zones as in the Big marsh.

In the stream flowing through the marsh diatoms were very abundant, but none of the green algæ common to the region were found. Along the stream *Scirpus campestris* Britton and *S. pungens* Vahl. were present, but *S. lacustris* L. was not seen.

On patches of overflow deposit were found *Distichlis maritima* Raf., *Polygonum ramosissimum* Michx., *P. Persicaria* L., *P. Hydro-*

piper L., *Amarantus chlorostachys* Willd., *Panicum Crus-galli* L., *Xanthium strumarium* L., and a single small willow, probably *Salix nigra* Marsh.

In isolated patches along the margin of the barren portion *Distichlis maritima* Raf., *Polygonum ramosissimum* Michx., and *Suæda diffusa* Watson, are usually the only plants present, but in some places *Hordeum jubatum* L. and *Sporobolus Texanus* Vasey come close to the border of the main barren. A little farther out *Iva ciliata* Willd. and *Atriplex expansa* Watson are common. Irregular patches, more or less inclosed by barren ground, contain *Distichlis maritima* Raf., *Polygonum ramosissimum* Michx., *Suæda diffusa* Watson, *Atriplex expansa* Watson, *Polygonum Hydropiper* L., *Solanum rostratum* Dunal, *Hordeum jubatum* L., and *Sporobolus Texanus* Vasey. In the next zone *Aster multiflorus* Ait. and *Ambrosia psilostachya* DC. are added.

In the south end of the marsh, where there seemed to be much overflow deposit, although the greater part was still quite salty, the following plants were found: *Helianthus annuus* L., *Ambrosia psilostachya* DC., *Euphorbia marginata* Pursh., *Polygonum ramosissimum* Michx., *Iva ciliata* Willd., *Suæda diffusa* Watson, *Ambrosia trifida* L., *Polygonum Persicaria* L., and *Datura Stramonium* L.

Euphorbia marginata Pursh, *Datura Stramonium* L., and *Chenopodium hybridum* L. were found as perfectly isolated plants in the barren portion.

In the outer part of the marsh much the same vegetation is present as in the Big marsh. *Solidago Canadensis* L., *Iva ciliata* Willd., *Ambrosia psilostachya* DC., *Helianthus annuus* L., *Atriplex expansa* Watson, *Hordeum jubatum* L., *Sporobolus Texanus* Vasey, and *Sporobolus heterolepis* Gray are the plants characteristic of the transition zone.

SUMMARY.

1. The salt marshes of northern Kansas are characterized by large areas absolutely destitute of vegetation; by the paucity of species around their margins; and by the entire absence of all woody plants.

2. The vegetation of the streams flowing through them consists of diatoms and the three sedges, *Scirpus pungens* Vahl., *S. campestris* Britton, and *S. lacustris* L.

3. The three characteristic plants in and about the barren portion are *Distichlis maritima* Raf., *Polygonum ramosissimum* Michx., and *Suæda diffusa* Watson, of which the Suæda is by far the least abundant.

4. The plants which may be regarded as successful invaders are the following: *Iva ciliata* Willd., *Sporobolus heterolepis* Gray, *Sporobolus Texanus* Vasey, *Atriplex expansa* Watson, *Aster multiflorus* Ait., *Ambrosia psilostachya* DC., and *Hordeum jubatum* L. *Sporobolus Texanus* Vasey has never been reported, I believe, beyond the southern part of Kansas. Its abundance in the northern tier of counties of Kansas extends its northern limit nearly two hundred miles.

5. Among the less successful invaders which are quite common are the following: *Panicum Crus-galli* L., *Panicum virgatum* L., *Euphorbia marginata* Pursh, *Euphorbia glyptosperma* Engel., *Chenopodium hybridum* L., *Polygonum Persicaria* L., *Polygonum Hydropiper* L., *Amarantus chlorostachys* Willd., *Datura Stramonium* L., *Solanum rostratum* Dunal, *Xanthium strumarium* L., *Helianthus annuus* L., *Œnothera biennis* L., *Gaura parviflora* Dougl., *Elymus Virginicus* L., and *Spartina cynosuroides* Willd.

COLUMBUS, OHIO.

SOME NEW AND OTHER NOTEWORTHY PLANTS OF THE NORTHWEST.

J. M. GREENMAN.

SPIRÆA DENSIFLORA Nutt. in Torr. and Gray Fl. 1:414.

S. betulæfolia Pall. var. *rosea* Gray, Proc. Am. Acad. 8:381. 1872.
S. lucida Dougl. var. *rosea* Greene, Pittonia 2:221, 1892.
S. arbuscula Greene, Erythea 3:63. 1895.

This showy alpine plant, which has recently attracted considerable attention, was originally collected and characterized as *Spiræa densiflora* by Nuttall, whose type specimen is preserved in the Gray Herbarium. The first publication of the above name, however, appears in Torr. & Gray's *Flora* 1:414, where the plant is briefly described as a roseate-flowered form of *S. betulæfolia*, and the name *S. densiflora* Nutt. MSS. cited as a synonym. In *Proc. Am. Acad* 8:381 Dr. Gray established a variety *rosea* of *S. betulæfolia* Pall., based upon Hall's no. 124, but this plant is exactly the same in every regard as Nuttall's *S. densiflora*, and in no respect more perfectly characterized. In 1892 Prof. Greene (*Pittonia* 2:221) transferred the variety to *S. lucida* Dougl., at the same time suggesting the probability of its being a distinct species, and later (*Erythea* 3:63) published the same as *S. arbuscula*. The examination of a considerable amount of material confirms Prof. Greene's view that this plant should have specific rank; and that it is quite distinct from *S. betulifolia* Pall. may be seen by a comparison with the excellent illustration of the latter species in Pall. *Fl. Ross.* 1:33. *pl. 16*, but there seems no reason for discarding Nuttall's name *S. densiflora*, which although briefly was intelligibly characterized in 1844. The possibility of *S. pyramidata* being the same as *S. densiflora* Nutt., as suggested by Prof. Greene in *Pittonia* 2:221, is quite out of the question. The two plants are very different in inflorescence, foliar characters, and color of the flowers.

A very excellent illustration of *S. densiflora* Nutt. may be found in *Gard. & For.* 10: *fig. 53*. It may be said, however, that the leaves are somewhat variable as to the serration, being crenate-serrate to rather sharply serrate. To this species may be referred: CALIFORNIA, Brewer 1777, 1932, [illegible]; Bolander 131; Lemmon, from Sierra Co. (in 1874); Torrey 131; Hansen [illegible]; J. D. Hooker and A. Gray, Hermits Valley: OREGON, Hall 125; Cusick 122 in part, as to small leaved, purple flowered, densely corymbose form: WASHINGTON, Henderson 245; E. C. Smith 354; O. D. Allen 57, 290; Piper [illegible]: WYOMING, Nelson 941: BRITISH COLUMBIA, mountain slopes in the Selkirk range, Macoun. Probably also extending northward to Alaska.

In the second century of Mr. O. D. Allen's distribution of Washington plants, no. 125 was distributed as *Pyrus sambucifolia* Cham. & Schlecht. It should be referred rather to *Pyrus occidentalis* Watson.

Polemonium bicolor.—A low cespitose perennial: the stems covered below by persistent attenuate sheaths, which remain behind as the remnants of the earlier leaves: flowering stems 6 to 18^{cm} high, glandular pubescent with a few long pilose hairs intermixed, 1–3-leaved: the basal leaves with somewhat dilated or clasping petioles; the leaflets 21 to 31 in number, obovate-rotund to oblanceolate, 4 to 6^{mm} long, 2 to 4^{mm} broad, glandular-pubescent with a strongly glandular-ciliate margin, more or less crowded or sometimes imbricated: inflorescence cymulose: peduncles 1^{cm} or less in length, glandular-pubescent: calyx [illegible] to 8^{mm} long, veiny, glandular-pubescent with long spreading pilose hairs intermixed; lobes oblong linear, obtuse, corolla with a deep yellow throat and a dark purple to whitish limb, narrowly funnelform, 12 to 16^{mm} long; tube slightly ampliated above, somewhat exceeding the calyx; the obovate lobes 5 to 7^{mm} long: stamens shorter than the corolla; filaments not appendaged at their pubescent bases: style slender, filiform, nearly as long as the corolla: capsule glabrous, 4^{mm} long, or about one-half as long as the more or less persistent calyx; seeds angular, 1.5 to 2^{mm} long.—Collected by O. D. Allen on Mt. Rainier, Washington, altitude 2460^{m}, August 8, 1897, no. 29[illegible]

To this species may be referred specimens collected by Suksdorf on Mt. Adams (Mt. Paddo), Washington, altitude $2150–2460^{m}$, August 9, 1882, no.

Howell, Mt. Adams (in 1882); Henderson 2411, East Mt. Adams; E. C. Smith 780, Mt. Rainier, altitude 2770^{m}, August 1890; O. D. Allen 62, Mt. Rainier; Piper 2129, Mt. Rainier, altitude 2770^{m}, August 1895.

A species well marked by its cespitose habit and glandular character, and especially by the long narrowly funnelform corolla, quite distinct from *P. humile* Willd. var. *pulchellum* Gray, with which it has been confused. The most nearly related species is the *P. Richardsonii* Graham, *Bot. Mag. pl. 2800*. A part of the type material of the latter species is in the Gray Herbarium, and it is a plant with larger nearly glabrous leaflets and somewhat broader calyx-lobes and less tubular corolla.

POLEMONIUM VISCOSUM Nutt. var. **pilosum**.—Stems 6 to 10^{cm} high; the entire plant covered with a spreading pilose pubescence intermixed with short glandular viscid hairs: leaflets usually less crowded or imbricated than in the type of the species: the calyx-lobes somewhat variable, oblong-ovate to distinctly oblong, obtuse or rounded at the apex: corolla white or pale blue with a yellowish center, 1^{cm} or less long.—Collected by O. D. Allen in clefts of rocks on Goat mountain, Washington, altitude 1540^{m}, July 6, 1896, no. 261.

Somewhat intermediate between the above variety and the species proper are specimens from Lassen's Peak, California, collected by J. G. Lemmon in 1875 (nos. 20, 960), referred by Dr. Gray to *P. humile* Willd. var. *pulchellum* Gray. Mr. Lemmon's specimens have the spreading pilose pubescent character of the variety, but to a much less extent, particularly on the calyx. There is also in the Gray Herbarium a specimen from Lassen's Peak, collected by Mrs. Austin in 1879, likewise referred to *P. humile* Willd. var. *pulchellum* Gray, which corresponds very accurately to Nuttall's type of *P. viscosum*.

Veronica Allenii.—Perennial: stems 6 to 8^{cm} high, nearly glabrous below, pubescent above: the lower leaves much reduced, the upper sessile, thickish, oblong or oblong-ovate, 10 to 14^{mm} long, 4 to 9^{mm} broad, obtuse, glabrous or with a few scattered hairs on the midrib and margin: inflorescence in a terminal raceme, glandular-pubescent: peduncles 2 to 5^{mm} in length, often exceeding the herbaceous glandular bracts: calyx unequally 5-parted; divisions oblong or oblong-ovate, obtuse or rounded at the apex, covered on the outer surface and along the margin with long slender glandular hairs: corolla 6 to 7^{mm}

in diameter, white or white with a slightly purplish puberulent throat; the upper lobe sub-rhombic, conspicuously emarginate, the lateral lobes ovate or ovate-rhombic, somewhat larger than the lower lobe: stamens exserted: ovary closely covered above with short glandular hairs; style exserted, about 5^{mm} in length: fruit not seen.—Collected by O. D. Allen along Paradise river on Mt. Rainier, altitude 1700^{m}, August 20, 1895, no. 95*a*.

A species habitally like *V. Cusickii* Gray, but differing by the somewhat smaller flowers, the white corolla, and less exserted stamens and style.

Castilleia oreopola.—Simple or many stemmed from a perennial base: stems erect, 1.5 to 3^{dm} high, somewhat furrowed by the inconspicuous decurrence of the leaves, below glabrous or nearly so, covered above with a scattered spreading soft pubescence: leaves sessile, oblong-lanceolate, 2 to 4^{cm} long, 5 to 10^{mm} broad, with one or two pairs of divaricately spreading linear-attenuate lobes, 3-nerved, glabrous or the uppermost covered with a soft spreading pubescence especially on the nerves and margins; the lower leaves much reduced, usually entire: inflorescence terminating the stem in a short close subcapitate raceme later becoming elongated: bracts 3-cleft to the middle, the lobes as well as the calyx of a "deep rose-purple:" calyx 18^{mm} long, about equally divided anteriorly and posteriorly for one-half its entire length; lobes oblong-linear, obtusish: corolla 2^{cm} long, the narrow exserted galea green on the back with thin subscarious deep rose-purple margins; lip included, rather deeply and subequally 3-lobed: mature capsule oblong, about 1^{cm} long, glabrous.—Collected by W. N. Suksdorf in damp ground, on Mt. Adams (Mt. Paddo), Washington, altitude 1840 to 2150^{m}, August and September, 1891, no. 2046, distributed as *Castilleia miniata* Dougl. var. *alpina* Suksdorf; O. D. Allen, Mt. Rainier, altitude 2150^{m}, July 20, 1892, no. 11; also by the same collector in open ground on Goat mountain, altitude 1540^{m}, July 12, 1895, no. 134, the latter distributed as *C. alpina* Greenman n. sp.

On account of the previous use of the name *alpina* in this genus by Porter it seems advisable to publish the species under the above name in order to avoid further and unnecessary change. A species readily recognized by the deep purple or almost magenta color of the bracts and flowers, and distinguished from *C. parviflora* Bong., its nearest ally, by the larger flowers, longer calyx, usually 3-cleft leaves, narrower and 3-lobed instead of 5-lobed bracts.

For some time it has been evident that the many forms under *Castilleia pallida* of American authors have constituted an extremely composite group. The recent activity among collectors of the northwest has brought to hand a considerable amount of complete material. A study of the group in the light of more copious material and recently collected specimens has made it possible to separate out as distinct species or varieties certain so-called forms hitherto included under *C. pallida.*

Castilleia pallida HBK. Nov. Gen. & Spec. **2**: 331. 1817; Kunth, Syn. Pl. Æquin. **2**: 100. 1823; Gray, Syn. Fl. **2**: 297. *Bartsia pallida* L. Spec. **2**: 602 (Gmel. Fl. Siber. **3**: 201. *pl. 42*). —Perennial: stems 1.5 to 3^{dm} or more high, rather sparingly pubescent below, covered above, especially in the inflorescence, with long somewhat matted hairs: leaves lance-attenuate, mostly entire, the upper usually broader and more or less lobed, short-puberulent on either surface: calyx about 2^{cm} long, cleft about equally before and behind, the lateral divisions again more or less 2-cleft; lobes linear-lanceolate, obtusish: corolla slightly exceeding the calyx; galea about 7^{mm} long, nearly or quite twice exceeding the rather prominently 3-lobed lip.—Originally collected in Siberia.

There is in the Gray Herbarium a specimen, from the Herbarium of the Academy of St. Petersburg, collected by Chamisso on the island of Chamisso. This plant has been taken as typical of the species.

CASTILLEIA PALLIDA HBK. var. **lutescens.**—Stems 3 to 5.5^{dm} high, somewhat stouter than the species, usually branched above: leaves linear-lanceolate to oblong-lanceolate, the lower entire, the upper often trifid or sometimes even with a second pair of lateral lobes, scabrous especially on the upper surface: lip-slightly shorter in proportion to the length of the galea than in the species proper.—Suksdorf 424, prairies, Spokane co., Washington, June 1884; C. V. Piper 1667, Pullman, Washington, June 26, 1893; Rev. H. H. Spaulding, Clear Water, Oregon; F. Lamson Scribner 197, near Jefferson City, Montana, June 27, 1883; Messrs. Sandberg, MacDougal, and Heller 450, Latah co., Idaho, June 20, 1892; Macoun 5, Sproat, B. C., June 24, 1890.

CASTILLEIA PALLIDA HBK. var. **camporum**.—Stems usually several rising from a perennial base, 1.5 to 4^{dm} high, more or less covered with a spreading pilose pubescence: leaves narrowly oblong-lanceolate, the lower mostly entire, the upper irregularly laciniately 3–7-lobed with rather narrow ascending lobes pubescent upon either surface: inflorescence greenish yellow or tinged with red, later becoming much elongated: calyx 2 to 2.5^{cm} long; lateral divisions again shortly 2-lobed (rarely entire), obtuse or even rounded at the apex; lip one-half to two-thirds as long as the galea.—Suksdorf 423, low prairies, Spokane co., Washington, June 1884; Piper 2514, Powder river mountains, Oregon, August 1896: Cusick 840, Union co., Oregon, 1879, in the Gray Herbarium under "*Orthocarpus castilleioides*;" also a duplicate specimen under "C. pallida fere vera." A specimen from Henderson, Lincoln co., Washington, 1892, no. 2266, seems to have its affinity here, as does also an imperfect specimen from the Herb. Geol. and Nat. Hist. Survey of Canada, collected by McEvoy, along Meadow creek, B. C., June 24, 1890, no. 2. In the latter specimen, however, the calyx is unusually long, being fully 3^{cm} in length.

The above variety appears to be intermediate between the species proper and the var. *occidentalis*, having more divided leaves and more spreading pubescence than the species, but approaching the var. *occidentalis* as shown by specimens collected by Scribner in the Little Belt mountains, Montana, no. 198, and also specimens obtained by Aven Nelson at Dome lake, Wyoming, no. 2435.

Castilleia pallescens.

Orthocarpus pallescens Gray, Syn. Fl. 2: 299.
O. Parryi Gray, Am. Nat. 8: 214.

The examination of a considerable amount of material shows that this species, hitherto somewhat doubtfully referred to Orthocarpus, has its affinity rather with the genus Castilleia. Notwithstanding the rather prominent lower lip and the short, broad galea, yet the very slight saccate character of the lip, and the calyx cut about equally before and behind with the lateral lobes shortly 2-cleft at the apex, combined with the perennial habit, all indicate its relation to Castilleia, and to the *C. pallida* group. In addition to the characters already given the following supplementary description may be appended. Stems 1.5 to 3^{dm} high, usually several rising from a woody perennial base, simple or sparingly branched above, cinereous-puberulent often with spreading pilose hairs, especially below.

Nuttall's specimen from the Rocky mountains; Parry 218, Northwestern Wyoming Expedition, 1873; Cusick 93, Union, Oregon, 1875; Canby, near Blackfoot City, Montana, July 11, 1883, no. 261 in part (as to specimens distributed under *Orthocarpus pallescens* Gray, not as to specimen distributed as *O. pilosus* Watson); Macoun, Kamloops, B. C., June 13, 1889; here also may be referred as more pubescent forms, Henderson 2267, 2268, 2269, Washington, and a plant of Dr. Lyall's Oregon Boundary Collection of 1860 originally distributed as "*Castilleja pallida* var.?"

Castilleia Cusickii.—Stems several from a procumbent base, 2 to 4.5^{dm} high, simple or branched above, green or greenish purple, covered with a short spreading or slightly reflexed cinereous pubescence: leaves scattered, sessile, 3-nerved, hirtellous-puberulent upon either surface, the lower leaves linear to linear-lanceolate, acute, 2 to 3^{cm} long, about 3^{mm} wide, the upper somewhat larger, 3.5 to 4.5^{cm} long, 3 to 5^{mm} broad, and usually laciniately lobed with one or two pairs of slender divaricately spreading lobes on either side, the veins beneath prominent: racemes rather dense, 3 to 10^{cm} long, 1.5^{cm} or less broad; rhachis covered with a long flaccid sublanate pubescence: bracts about equaling or slightly exceeding the flowers, oblong, obtuse, or rounded at the apex, usually undivided and entire, strongly ciliate toward the base, distinctly 3-nerved, and rather strongly reticulate-veined, 23 to 28^{mm} long, about 7^{mm} broad: flowers 2 to 2.5^{cm} long: calyx pubescent on the outer surface, nearly equally divided anteriorly and posteriorly; the lateral divisions linear-oblong, 2-dentate or shallowly 2-lobed at the apex, prominently 2-veined even to the base of the calyx: corolla 2 to 2.5^{cm} long, slightly exceeding the calyx, but scarcely twice the length of the rather prominent but not saccate 3-lobed lip: only the two anterior stamens protruding beyond the lip: style somewhat exceeding the galea, shallowly 2-lobed: capsule oblong, about 1^{cm} long, 4^{mm} broad, glabrous.—Collected by William C. Cusick in Sumter valley, Blue mountains, Oregon, July 6, 1897, no. 1700. The flowers are said by the collector to be "pale yellow rarely tinged with red."

A species related to *C. pallida* HBK., from which it is distinguished by the foliar characters, pubescence of the stem and leaves, and the long, slender inflorescence.

Castilleia levisecta.—Many-stemmed from a perennial base: stems 1.5 to 3^{dm} high, usually unbranched above, covered with a soft more or less spreading unequal pilose pubescence: leaves oblong-lanceolate, 2.5 to 4^{cm} long, 5 to 12^{mm} broad, 3–5-nerved, pubescent upon either surface, often bearing rather long pilose hairs on the veins beneath: the lower somewhat narrower and often entire; the upper more dilated and shallowly lobed toward the apex with one to three pairs of lobes on either side: inflorescence rather densely spicate or subracemose: bracts yellow rather broad, subdigitately lobed at the apex: calyx 15 to 18^{mm} long, nearly equally cut before and behind, externally pubescent; the lateral lobes again rather deeply 2-lobed, obtuse or rounded at the apex: corolla 2^{cm} or more long; galea 6 to 8^{mm} long; the lip one-third as long as the galea, shortly and obtusely 3-lobed: capsule glabrous, 8 to 10^{cm} long, usually covered by the persistent pubescent calyx.—Howell 279, Mill plain, Washington, 1880, O. D. Allen 83, Roy, Washington, May 19, 1886; F. Binns, in open woods and hills, Pt. Ludlow, Washington, June 15, 1890; Macoun 715, vicinity of Victoria, Vancouver Island, B. C., May 16, 1893.

A species hitherto confused with *C. pallida* HBK., but differing materially in the foliage, and in the character of the lip of the corolla.

Castilleia cervina.—Cinereous-puberulent throughout: stems simple, 6^{dm} or more high, somewhat striate above: leaves usually deeply 3(–5)-parted, with the lateral divisions linear-attenuate and divaricately spreading: the lower flowers of the spicate inflorescence short-pedicellate: bracts laciniately 3–5-lobed, lobes ascending, these as well as the calyx and corolla, in the dried state, tipped with yellow: calyx 1.5 to 2^{cm} long, more deeply cut before than behind; the lateral lobes again shortly and acutely bilobed: corolla 2 to 2.5^{cm} long; galea about 6^{mm} long; the lip nearly or quite one-half as long as the galea, lobes conspicuous and subequal: stamens and stigma exserted.—Collected by Dawson on dry ground, Lower Arrow Lake, B. C., June 17, 1889; and in the same locality by Macoun, June 5, 1890, no. 11.

Most nearly related to *C. breviflora* Gray, from which it is readily distinguished by the taller habit and the pubescence of the inflorescence.

NEMACLADUS RIGIDUS Curran. This interesting little plant, hitherto known only from the type locality, was collected by Mr. Cusick on the hillsides of the Malheur, Oregon, June 1897, no. 1625.

GRAY HERBARIUM OF HARVARD UNIVERSITY.

BRIEFER ARTICLES.

NOTES ON CAREX. XIX.

Carex Madrensis, n. sp.—One of the INDICÆ, and, with *C. Schiedeana* Kunze, making a well-marked section of that group: slender, a foot to eighteen inches high, with short and flattish leaves: spikes about four, aggregated, or the lowest one or two remote and long-peduncled from sheaths, a half inch long, and ovate or nearly globular, the apical staminate part very short: perigynium obovoid and slightly excurved, distinctly and abruptly beaked, the orifice slightly toothed, the beak trigonous and strongly few-nerved, somewhat scarious, but not hairy or pubescent: scale broad and blunt, with a short cusp, brown, with a dorsal nerve, shorter than the light-colored perigynium.

Differs from *C. Schiedeana*, its nearest relative, in its much laxer habit and softer leaves, the absence of long bracts subtending the upper spikes, the more scattered spikes, the long peduncles of the lower spikes, the glabrous less-nerved perigynium, and the broader and blunter scales.—Near the top of the Sierra Madre mountains, State of Durango, Mexico, *J. N. Rose* 2357. 1897.

Carex Seatoniana, n. sp.—Allied to *C. spissa* Bailey, but less stout, spikes loosely flowered, perigynia ascending and thinly haired or hispid: plant five or six feet high, with stiff, rough-edged, light-colored leaves: spikes about ten, half of them pistillate, with short staminate tips, the lower ones long-stalked and five or six inches long, narrow and loosely flowered: perigynium ovate to obovate or almost turbinate, firm and not inflated, strongly few-nerved, short-beaked, with the orifice entire or nearly so, sparsely hispidulose, often puncticulate: scales awl-like and serrate, or becoming broad and merely cuspidate near the apex of the spike.

A well-marked plant, with scattering perigynia in the midst of the long spikes, and more densely flowered near the apices, all the scales below the tips very long and prominent.—Moist river bluffs, near Tula, Mexico, *Pringle* 7452. 1897. Dedicated to the memory of Henry E. Seaton, late assistant curator of the Gray Herbarium and student of Mexican plants.

Carex galbana, n. sp.—Related to *C. triceps* Michx.: a weak plant, with slender curving culms a few inches to a foot long, much overtopping the short flattish leaves: spikes two or three, small (half inch or less long), aggregate, staminate below, the bracts not prominent or leafy: perigynium trigonous-turbinate, greenish and glabrous, strongly many-nerved, the beak scarcely any, and orifice entire: scale thin and brownish, blunt, narrower and shorter than the perigynium.

Differs from *C. triceps* and its varieties in its very different habit, glabrous surface (leaves very sparsely ciliate on the edges near the base), and the absence of leafy bracts.—Sierra de las Cruces, 10,000 feet, State of Mexico, *Pringle* 7083. 1896.

Carex irrasa, n. sp.—(*C. Douglasii* Boott var.? *laxiflora* Bailey, Mem. Torr. Bot. Club **1**: 20.)

Aside from the original specimens collected by Williams near Utica, Montana, I now have the plant from Big Lost river, Idaho (*Henderson* 3698). It seems to have little in common with *C. Douglasii*, to which I provisionally referred it, being distinguished by its open brown simpler head and looser-flowered spikes, taller and more slender habit, often rough-angled perigynium, and shorter styles.

Carex turgidula, n. sp.—Allied to *C. acutina* Bailey and *C. stricta* Boott var. *decora* Bailey, but distinguished from all members of this group by its thin and turgid perigynia and spreading-pointed black scales: erect and stout, 12 to 18 inches high, the culms overtopping the flat bright green leaves: pistillate spikes one to three, approximate near the top of the culm, varying from a half inch to an inch and a half long, the lowest one or two very short-stalked and subtended by rather short leaf-like bracts, most of them with a staminate apex: perigynium thin and globular or turbinate, very abruptly contracted in a very short entire beak, nerveless except on the angles, turgid or inflated, longer than the black-brown pointed spreading scale.

Stewart's Lake, British Columbia (*Macoun*); near Portland, Oregon (*Henderson*); Lake Waha, Nez Perces county, Idaho (*Heller* 3400).

Carex Oaxacana.—I propose this name for the *C. olivacea* of Liebmann. Mr. Pringle collected the plant at an altitude of 9000 to 10,000 feet, on the Sierra de San Felipe, Oaxaca (no. 4842) in 1894. It is a well-marked species, allied to *C. virescens* Muhl., but with narrow-[illegible] and distinctly beaked glabrous perigynia and stiffish sparsely hairy herbage. The synonymy of this much named plant is as follows:

C. olivacea Liebm. Mex. Halv. 79 (1850), not Boott (1846).

C. monticola Boeckl. Engler's Bot. Jahrb. **1** : 364 (1881), not Dewey 1861).

C. androgyna Bailey, Proc. Amer. Acad. **22** : 101 (1886), not Balbis.

Liebmann reports it from the Peak of Orizaba.

CAREX OBLATA Bailey, var. **luzuliformis,** n. var.—Differs from the species in being much taller (two feet or more), with broader leaves and much larger spikes.

Idaho, Oregon, California. It is 6210 of the California Geological Survey and 1426 of the Department of Agriculture Death Valley Expedition (*Coville & Funston*). In some cases I have confounded this with *C. luzulæfolia* W. Boott, but that species differs in its broader foliage, and particularly in its broader, papery, and more turgid perigynia. The perigynia of *C. oblata* and var. *luzuliformis* are long and gradually tapering, hard and not at all inflated.

L. H. BAILEY, *Cornell University.*

THE SYSTEMATIC POSITION OF THE GENUS MONOCLEA.

THE genus Monoclea, according to Schiffner,[1] contains one certainly known species, *M. Forsteri* Hook., and a second one, *M. dilatata* Leitgeb, which Schiffner thinks should probably be united with *M. Forsteri*. The American form of the latter has been separated as *M. Gottschei* by Lindberg, but is not usually considered to be distinct.

Monoclea Forsteri is apparently common throughout tropical America, and during a visit to Jamaica in the summer of 1897 I met with the plant repeatedly in the wet mountain ravines, and upon the dripping rocks along the margins of streams. In such situations the plant occurred in large masses and was very conspicuous.

Hooker's original description[2] I have not seen, but from the reference to this in Gottsche's paper,[3] it must be very incomplete, as there was an evident confusion of the plant with Anthoceros and Dendroceros. The locality from which the original plant came seems also to be doubtful.

The first account of the plant which is at all complete is that given by Gottsche in the paper already referred to. Leitgeb[4] in his great work upon the Hepaticæ made some additions to Gottsche's description and corrected his error as to the origin of the archegonia. Both of these observers studied the female plant only, but in the last part of this work,[5] Leitgeb describes the male plant of what he considered a distinct species, to which he gave the name *M. dilatata*. The specimens came from New Zealand and were supposed to be a species of Dumortiera, which Monoclea resembles very closely in general habit. Finally Ruge[6] has added materially to our knowledge of the plant, especially as regards the development of the reproductive organs.

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[1] ENGLER and PRANTL, Die natürlichen Pflanzenfamilien 91–92 : 56.

[2] HOOKER, Musci exotici. London, 1820.

[3] GOTTSCHE, Ueber das Genus Monoclea. Bot. Zeit. **19** : 281–289. 1858.

While Gottsche and Leitgeb both recognized the obvious resemblance of the thallus of Monoclea to that of Dumortiera, they concluded that the complete absence of the characteristic lacunae of the marchantiaceous thallus in the former forbade its being placed in the Marchantiaceæ, and that its nearest affinity was with the thallose Jungermanniaceæ like Pellia and Pallavicinia.

A careful examination of the material collected by me last summer, as well as a study of the observations made by Leitgeb and Ruge, have convinced me that the genus should be removed from the Jungermanniaceæ to the Marchantiaceæ with which it much more closely agrees. The form of the thallus and the character of the apical cell were recognized by Leitgeb as marchantiaceous, but as the air-chambers were quite absent he concluded that this resemblance was purely superficial. While admitting the absence of lacunae in some forms of Dumortiera, he claimed that these were always formed in the youngest part of the thallus and were destroyed later. However, a careful examination by the writer[7] of *D. trichocephala* showed that in this species these were completely absent from the beginning, and the structure of the thallus corresponded in every respect with that of Monoclea. The most marked difference between the latter and the other Marchantiaceæ is the absence of the ventral scales, which are here represented only by papillate hairs of very brief duration. These, however, correspond in origin with the scales of the ordinary types, and simply remain undeveloped.

Monoclea, unlike any of the Jungermanniaceæ, has two sorts of root-hairs, thin-walled ones like those of the latter, and thick-walled rhizoids which are doubtless the homologues of the characteristic tuberculate ones of the typical Marchantiaceæ.

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[4] LEITGEB, Untersuchungen über die Lebermoose 3:62.

[5] Op. cit. 6:131.

[6] RUGE, G., Beiträge zur Kenntniss der Vegetationsorgane der Lebermoose. Flora 77:279. 1893.

[7] CAMPBELL, D. H., Mosses and Ferns 49. 1895.

It is the structure and arrangement of the sexual organs, however which prove the close affinity of Monoclea with the Marchantiaceæ. Both Leitgeb and Ruge noticed the extraordinary resemblance of the male receptacle to that of such forms as Conocephalus or Fimbriaria, and Ruge's figures show that the development of the antheridium is thoroughly typical of the Marchantiaceæ, although he makes no mention of this fact in the text.

The origin of the archegonia is exactly as in Targionia, and I have found that there are six rows of neck-cells, as in the Marchantiaceæ, instead of the five regularly found in the typical Jungermanniaceæ.

It seems strange that Ruge did not recognize the obvious marchantiaceous character of the reproductive organs, but he passes over this point without comment. Schiffner[8] places the genus in the Jungermanniaceæ, near Pallavicinia and Symphyogyna, although admitting marked differences in the character of the sporogonium.

In regard to the exact position of Monoclea, it will not be possible to decide until more is known of the development of the embryo. At present it seems to approach Targionia more nearly than any other genus. The resemblance to Dumortiera is probably purely superficial, and simply indicates a similar adaptation to similar semi-aquatic environment.

We may safely conclude that the affinities of Monoclea are with the lower series of Marchantiaceæ, perhaps the Targionieæ, where the archegonia are borne directly upon the unmodified thallus, and no definite receptacle is developed. The absence of lacunae, as well as the simplification of the rhizoids and ventral scales, are with little question secondary, as they are in Dumortiera, where, however, the reduction is not quite so marked; and these reductions are correlated with the almost aquatic nature of these plants. There is little reason to suppose that the two genera are closely related, as Dumortiera shows undoubted relationship with the higher Marchantieæ, like Marchantia, where both antheridia and archegonia are borne upon specially modified receptacles which are compound, representing a branch-system. Monoclea may be supposed to bear the same relation to the lower Marchantiaceæ that Dumortiera does to the higher ones.—DOUGLAS HOUGHTON CAMPBELL, *Stanford University.*

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[8] ENGLER and PRANTL, loc. cit.

THE ROCKY MOUNTAIN SPECIES OF THERMOPSIS.

(WITH PLATE XVIII)

THE difficulty of fitting all my specimens to the accepted descriptions of the heretofore published species of Thermopsis long since led me to suspect that more than two species were represented in this region. Of this I became convinced when perfectly typical material of *Thermopsis montana* Nutt. was secured in the western part of the state in 1897. The plant, common on the streams near Laramie, which I had long supposed to be that, and of which I had not heretofore secured fruits, turned out, as the fruits show, to be a very different one.

A closer examination of the characters of *T. rhombifolia* Rich. reveals also that some of the specimens that I had unwillingly placed under this name are, instead, a good species. *T. rhombifolia* differs from this in its habitat, mode of branching, its inflorescence, and other characters pointed out in the description. In looking over the recent description of *T. rhombifolia* in Britton and Brown's *Flora* it seemed to me probable that the measurements given, especially of the leaves, were hardly great enough.

The species of this region, as they now appear to be, are *T. montana*, *T. rhombifolia*, and the two proposed species. The fruits of these are very characteristic, a fact shown in the accompanying plate. The four fruiting racemes are all from Wyoming material, are mature and typical each of its species. They were photographed on one plate, hence the size is relatively correct (about one-third natural size).

Thermopsis divaricarpa, n. sp.—Erect, 5–8^{dm} high: stems several from the perennial root, youngest slightly pubescent especially upwards, nearly simple, bearing only two or three slender sterile branches from the upper axils, one or two of these generally overtopping the matured raceme: leaves large; leaflets sparsely appressed pubescent beneath, rhomboid or narrowly elliptic to oblanceolate, from acute to rounded obtuse, 5–10^{cm} long, 1.5–3.5^{cm} wide, nearly sessile: petioles 2–3^{cm} long; stipules large, ovate or the uppermost on the sterile branches narrower, somewhat inequilateral, longer than the petioles (3–5^{cm}): raceme strictly terminal on the main axis, rather dense: flowers large, yellow, about twenty; pedicels stout, 1^{cm} long, longer in fruit: calyx large, lobes shorter than the tube, the sinus between the two united upper lobes shallow: pods large, linear, 8–10$^{\mathrm{cm}}$ long, about 7$^{\mathrm{mm}}$ wide, finely pubescent when young, obscurely so when mature, from nearly straight and erect when young to divaricate and slightly curved when mature, 10–15-seeded.

It is found near streams, preferring the moist, rich soil among the open underbrush. Type specimens in Herb. Univ. of Wyo., no. 3424 by Elias Nelson, Pole creek, July 22, 1897; and no. 3903 by the writer, Johnson's ranch, Big Laramie river, August 8, 1897.

Thermopsis arenosa, n. sp.—Smaller in every way: stems from the persistent branched bases more numerous, branching and habit similar, 3–4$^{\mathrm{dm}}$ high: leaflets proportionately wider, from oblong or oblanceolate to obovate, 3–4$^{\mathrm{cm}}$ long, 1–2.5$^{\mathrm{cm}}$ wide; stipules longer than the petioles, broad, from ovate to suborbicular: fruiting racemes shorter: pods inclined to be divaricate from the first, shorter, at maturity constricted between the fewer large seeds.

These two species are very different in seasonal development and habitat. This last is very abundant in the Laramie hills in dry, open, sandy, or stony draws and ravines. Heretofore confused with *T. rhombifolia* from which it differs in its larger leaflets, longer stipules, its strictly terminal raceme and its curved, divergent, loment-like pod.

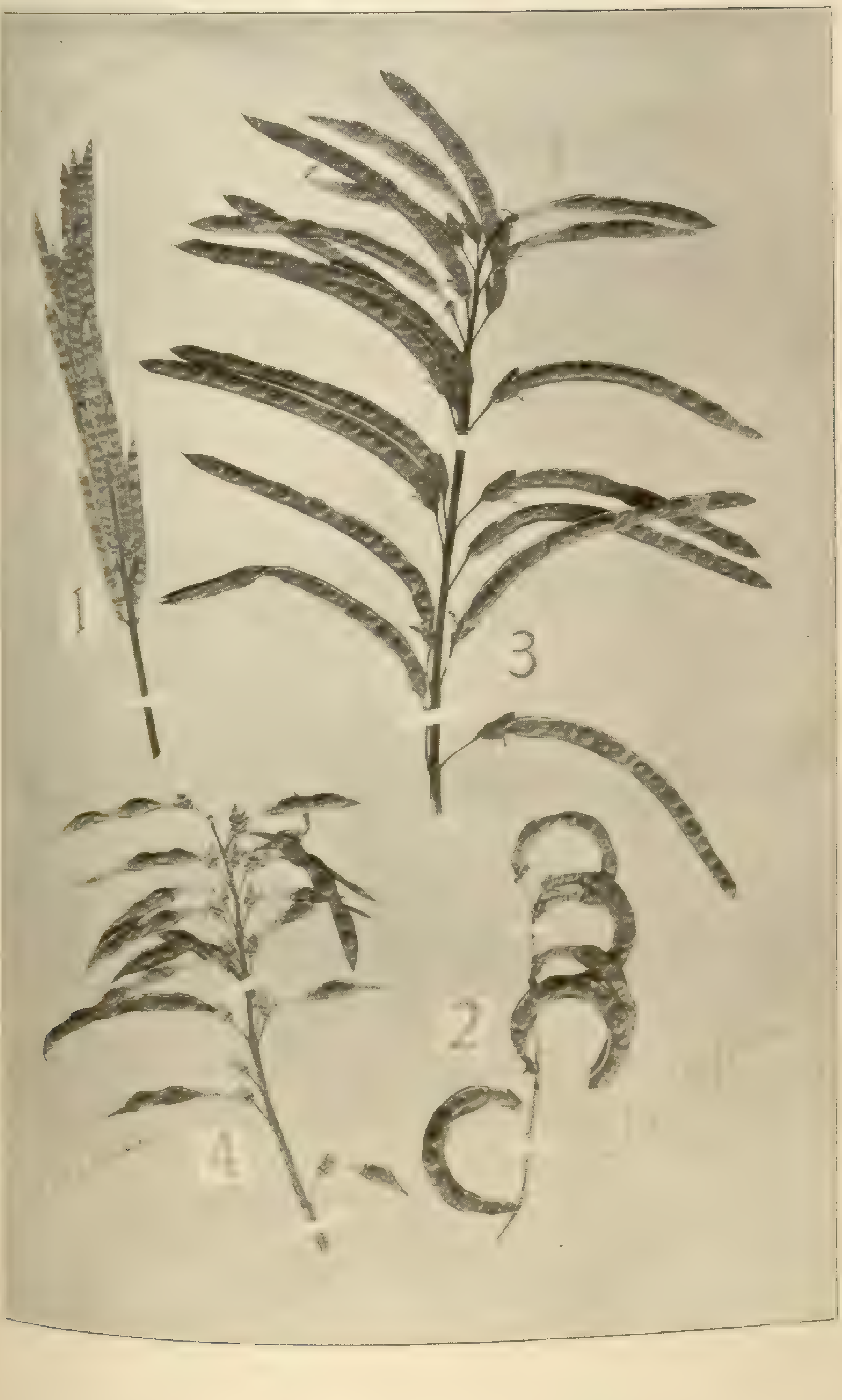
Type specimen in Herb. Univ. of Wyo., no. 3182, Laramie hills, June 16, 1897; fruit from the same locality July 17, 1897. Others nos. 122 and 1240.—AVEN NELSON, *The University of Wyoming.*

EXPLANATION OF PLATE XVIII.

FIG. 1. *Thermopsis montana* Nutt. FIG. 2. *T. rhombifolia* Rich. FIG. 3. *T. divaricarpa* Aven N. FIG. 4. *T. arenosa* Aven N.

NOTES ON THE BOTANY OF THE SOUTHEASTERN STATES. I.

HAVING the opportunity to study a considerable collection of plants gathered mainly during the past few years at various stations in the southeastern United States, I have decided to publish at intervals the results of the investigation so far as they relate to species that appear to be either undescribed, unrecorded in the recognized flora of the region, or of too restricted geographical range as indicated in recent literature on the subject. In the present paper one species is proposed



NELSON on THERMOPSIS.

new, one is raised to specific standing, two suppressed species are restored, and the heretofore recorded range of others greatly extended.

PHILADELPHUS LATIFOLIUS Schrad. DC. Prodr. 3 : 206. 1828.—An ignored and much confused species closely related to the European *P. coronarius* L. Abundant material in fruit collected on the rocky banks of the Cumberland river near Nashville, Tennessee, August 17, 1897, so clearly illustrates the validity of the species that I concur with Engler[9] in his statements regarding it, especially as to its frequent occurrence in cultivation and the confusion of American botanists. However, I know no other habitat than middle Tennessee. Torrey and Gray[10] referred all of Schrader's species published in the Prodromus[11] to *P. grandiflorus* Willd., or to forms of the same, a position not wholly sustained by recent writers, and their variety *floribundus* is truly the species at issue.

Philadelphus latifolius differs from *P. grandiflorus* in bearing flowers in naked racemes (sometimes a lower pair axillary) 5–9 but mostly 7-flowered, by the much smaller capsules; narrower, more pubescent calyx lobes; the 5-nerved leaves, which on young shoots are large and broadly ovate; and by the light colored bark. I have seen a flowering specimen of this fine species in the Philadelphus material of the National Museum, collected by Dr. Gattinger in 1888 from the same locality and distributed by A. H. Curtiss as *P. hirsutus* Nutt., where it is associated with fruit of the last named species. It is very common on the limestone bluffs of the Cumberland river in middle Tennessee, and its distribution will doubtless be found to cover a much wider area when the species is better known.

RUDBECKIA PINNATILOBA (Torrey & Gray).

R. triloba pinnatiloba Torr. & Gray, Fl. **2** : 309. 1841–1843.

Heretofore known only from the state of Florida, where it was collected and distributed by Dr. Chapman. On August 2, 1897, quantities of the same distinct plants were found on the dry slopes of Cedar Cliff mountain, Buncombe county, North Carolina, that match the Florida material as represented by the Chapman specimens at Biltmore, and, according to Dr. Small, similar material at Columbia University. From a study of the material, which embraces a large range of specimens, I am persuaded the plants should be regarded as full standing. The only other name that has been applied to the species, it seems, is *R. biennis* Chapm. in MSS., as cited by Torrey & Gray. *Rudbeckia pinnatiloba* not only differs from *R. triloba* in the form of the leaves, but by its lesser size, more pubescent stem, smaller heads and earlier time of flowering.

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[9] Die natürlichen Pflanzenfamilien III. **2a** : 71. 1891.

[10] Flora N. Am. **1** : 595. 1838–1840.

[11] DC. Prodr. **3** : 205–206. 1828.

JUNCUS TRIFIDUS L. Spec. Pl. 326. 1753.—From the published statements regarding the range of this species it would seem that no authentic stations south of New York have been recorded. On J[illegible] 8, 1897, and several days later, *Juncus trifidus* was found in abundance growing from the crevices of the rocks on the summit of Craggy mountain (2000^m elevation), Buncombe county, North Carolina.

Polymnia lævigata, n. sp.—Perennial herb, 0.5 to 1^m high, slender, branching: leaves thin-membranaceous, the upper deltoid-ovate with edges irregularly lacinate-dentate and the apex long acuminate, the lower broadly oval in outline, pinnately 5–7-lobed, the divisions acuminate; the upper surface along the veins puberulent, below minutely resinous atomiferous; upper surface of the petioles and a broad line along the stem and branches more or less purple and puberulent, especially at the nodes: heads loosely paniculate, nodding, light yellow: rays 3–5: ligule 3-lobed and almost white: achenes sparingly puberulent to glabrous, 5-costate and with an elevated epigynous disk at the summit: disk flowers campanulate, abruptly contracted into a long narrow tube, the lobes fimbriate and acute: the outer scales obovate, the inner oblanceolate, more or less fringed.

A most remarkable and distinct species collected at Cowan, Tennessee, August 21, 1897, and finding its nearest relative in *P. Canadensis radiata* Gray, from which it may be separated by the long acuminate lobes of the leaves, the 5-costate achenes, smaller size and almost glabrous stems and leaves.

VIOLA TENELLA Muhl. Cat. 26. 1813.—I cannot feel that there is any doubt about this species being truly indigenous. In rich, but shallow soil, on the rocky summit of Cedar Cliff mountain (113[illegible] elevation), Buncombe county, North Carolina, *Viola tenella* was found in flower, April 9, and again May 11, 1897, in fruit. In this situation, where there is but the remotest possibility of adulteration of the flora, the species is most abundantly represented. An interesting note in this connection is preserved in the Chapman Herbarium, where it is associated with material collected in the cedar barrens of Tennessee, and written by Dr. Gattinger, as follows: "Can impossibly be an introduced plant! Is one of the characteristic spring plants of the cedar barrens."

Amorpha glabra Desf. Cat. h. Par. 192. 1804.—Much uncertainty regarding the genus Amorpha as represented in the south Atlantic states is plainly displayed by writers, and with a view to clearing away some of this uncertainty I propose the restoration of a neglected species. Torrey & Gray[12] give a description of *A. Caroliniana* Croom (*A. gymnostachya* Curtis), a name they replace on page 690 of the same work by *A. glabra* Desf., and it is remarkable that this plant should in later times be associated with *A. fruticosa* L.[13] I have not at hand the original description of Desfontaines, and that in the Prodromus[14] is at best poorly applicable to Croom's *A. Caroliniana*, but on the evidence of Torrey & Gray, as above cited, I adopt the name and append a more tenable description.

A suffrutescent perennial, $1-1.5^{m}$ high, nearly glabrous. Stems several, slender, erect or ascending and leafy throughout, purplish and more or less verrucose: leaves $1.5-2^{dm}$ long, $3-4^{cm}$ wide: leaflets 12–20 pairs, oblong or elliptical, petiolulate, stipellate, punctate and apiculate by the excurrent midrib: spikes $1.5-2^{dm}$ long, panicled, densely flowered: calyx glandular, more or less villous on the margins of the unequal or dissimilar teeth, short pedicelled and the tube furrowed: vexillum violet blue: style hairy: pod one-seeded, $4-5^{mm}$ long, 2^{mm} broad, glandular roughened, the dorsal suture straight.—Low, sandy pine barrens from North Carolina to Florida as shown by specimens in the Biltmore Herbarium.

A. glabra may be distinguished from *A. herbacea* Walt., to which it is very closely related, by its smoothness, more slender habit, and bright colored flowers; from *A. virgata* Small by the diminutive legumes, smaller and twice as numerous leaflets; and from *A. fruticosa* by the straight dorsal suture of the small, one-seeded pods. I have observed no intermediate forms that would warrant the consideration of *A. glabra* as a variety of *A. herbacea*.

Stylosanthes riparia Kearney, Bull. Torr. Bot. Club **24**: 565. 1897. Specimens that agree substantially with the characters assigned to this species have been collected in Florida by Dr. Chapman, in Delaware by Mr. Canby, and in eastern North Carolina by the Biltmore Herbarium. All of the material, except possibly that from Delaware, compares favorably with Mr. Kearney's specimens collected in Cocke county, Tennessee, in habit, lobing of the vexillum and peculiarities of loment. In the plants from Delaware the vexillum is not constantly lobed, differing in this respect, indeed, on the same individual. —C. D. BEADLE, *Biltmore Herbarium.*

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[12] Flora N. Am. **1**: 305. 1838–1840.

[14] DC. Prodr. **2**: 256. 1825.

[13] Sereno Watson, Bibliog. Index 188. 1878.

THE GUM OF CANNA.

WHEN a freshly cut tuber of Canna is exposed to the air, there may be observed upon the cut surface, after some hours, the formation of small colorless or pale yellow drops, which stiffen rapidly in the air. From these there finally develop spherical masses of no mean size. Their color varies from very pale yellow to brown or bottle-green. When fractured they show a glistening and conchoidal appearance. The substance has the character of a gum. It is insoluble in water, even after long boiling, and it swells up in precisely the same way as do the gums of the cherry and apple.

When heated upon a platinum knife this gum of Canna swells up, chars, and then burns with a smoky flame, leaving considerable very white and light ash. This ash contains calcium carbonate, magnesium, iron, potassium, and phosphoric and hydrochloric acids.

For the study of the method of the formation of this gum, it was found convenient to use rootstocks which had first been macerated in strong alcohol. Sections were examined, either at once upon being made, or after having been subjected to a double stain produced by successive immersions in a hydro-alcoholic solution of red extract of Cassella, and a similar solution of acid green JEEE (Poirrier).[15] The washings were made in water containing alcohol, and the sections mounted in carefully prepared neutral glycerine.

Staining with haematoxylin gave poor results, probably on account of the resistance offered to its diffusion by the insolubility of the gum.

Upon first examination of the preparations one is tempted to assume

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[15] I prepared these solutions according to the following formulæ:

Rouge de Cassella	0.25gm	Acid green JEEE (Poirrier)	0.10gm
Alcohol at 90%	20.00gm	Alcohol at 90%	20.00gm
Distilled water	30.00gm	Distilled water	30.00gm

to the gum-bearing tissue of Canna a schizogenous origin. It certainly presents an aspect very suggestive of gum secreting cavities.

The fact is, however, that very little of the gum makes its first appearance upon the cell walls. It forms in thick layers in the cell interior, and, gradually condensing, forces the cytoplasm and its contents into the center. Little by little this alteration extends into neighboring cells. The condensation of the protoplasm is constantly increased in the central cells, whose walls seem to thicken as the membrane increases in volume. At a certain point the protoplasm and the thickened membrane surrounding it blend into a mucilaginous mass. This transformation may appear at first either in a single cell, or in a little group of cells always placed near the center of the mass. In no case did I notice any such intercellular space surrounding the secreting cells as occurs in the ordinary method of formation of secreting canals. The gum of Canna is formed in a lysigenous way, just as are those of the acacias, of fruit trees, and especially of the aralias. As gelatinization continues the gum-bearing region spreads, and tends to form pockets of varying form and dimension.

Formations of the same kind may occur in the fibrovascular bundles. Gelatinization is produced first in the wood and woody parenchyma. The gum then penetrates into the vessels, probably by osmosis; the walls of the vessels become gelatinized in their turn, and the whole bundle is transformed into a gum bearing cavity.

There should also be noted the extreme diminution of amidon in the neighborhood, which immediately succeeds the mucilaginous modification.

I have studied the same point in a large number of stems of other Marantaceæ taken from dried specimens in the Museum d'Histoire Naturelle, and from the Ecole supérieur de Pharmacie de Paris. In none have I found an analogous formation.— M. L. LUTZ, *Paris, France.*

CURRENT LITERATURE.

BOOK REVIEWS.

An elementary botany.

THE TASK of writing an elementary text-book that shall be satisfactory from the pedagogical as well as the scientific point of view is not an easy one, and the result is at best but a compromise in which the instructor's necessities should predominate in the selection of material for presentation. With these facts at hand it must be acknowledged that it is well-nigh hopeless to attempt to produce a manual which shall meet the conditions existing in any great number of schools. The last few years have seen the appearance of many such books in America, which met with no favor outside of the sphere of the personal influence of the author.

The recent effort by Mr. Groom[1] deserves attention. The book is written for students not furnished with compound microscopes and attendant facilities, which are both needless and harmful to young beginners. The author is examiner in botany to Oxford University, and has presumably selected the material for his book with reference to the requirements of English schools. The contents include general morphology, classification of the angiosperms and physiology.

About one hundred pages are devoted to the segmentation and development of the root and shoot, together with the mechanism of reproduction. A large proportion of this space is devoted to definitions of morphological areas in which it is scarcely necessary to say that accuracy and conciseness are well shown. The subjects of pollination, fertilization, and seed dispersal are more sensibly treated here than in any elementary text which has yet appeared. Omission of consideration of lower forms is, of course, to be taken for granted.

Under classification, descriptions of thirty important or common families are given.

The section of forty pages devoted to physiology has been so written that no knowledge of histology is assumed, an innovation which will be much appreciated by instructors, and which might well be taken into account in the preparation of more advanced manuals. The principles of physiology are treated with a simple directness of statement that is much to be commended. And further illumination is obtained by the outlines of easy demonstrations and experiments to accompany the context. The illustrations are clear and well selected throughout, and many of the best are original. The book will be found very useful in American as well as in English schools.—D. T. MACDOUGAL.

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[1] GROOM, PERCY.—Elements of Botany. 16mo. pp. x + 252. *figs.* 250. London. New York: George Bell & Sons. 1898. 3*s*. 6*d*.

Cultivated plants of Asia Minor.[2]

IN A BOOK of 278 pages devoted to the natural resources of Asia Minor, Kannenberg has given something over one hundred pages to the cultivated plants of the region. The account is a contribution to agriculture and current history rather than to botany, but the student of cultivated plants will find it useful nevertheless, since it attempts to make an annotated inventory of all the leading plants cultivated or used for food, used in the industries, for ornament and the like, and also an account of forests and timbers. The botanical names of the various species are not given, and this detracts from the value of the book for specific reference, particularly in such confused groups as the rose and the cucurbits. Very full references are given to the literature of the various entries, and the reader will find much of interest in the discussions of local and geographical names for species and varieties. The book is essentially a compilation, the work of Hehn and others being laid under heavy tribute. There are many striking half tones. The book seems to be a distinctly good contribution to the popular knowledge of the immediately useful natural history of the region.— L. H. BAILEY.

The ferns of the earth.

Dr. H. Christ[3] has published a general systematic account of ferns which is intended for popular rather than for technical use. This group has always been an attractive one for general presentation, ever since the *Synopsis Filicum* of Swartz in 1806. The last general presentation was the *Synopsis Filicum* of Hooker and Baker, edition of 1883.

The author restricts himself in various ways, so that the work may not be too bulky, and still may be a good general presentation of ferns. He confines himself to the homosporous Filicineæ, with their leptosporangiate and eusporangiate groups. Moreover, he does not include doubtful species, or even doubtful genera, attempting to present only those genera and species which are well established and representative. Of course his work is intended merely for those interested in determining ferns, and it stops precisely at the point where interest for the specialist begins.

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[2] KANNENBERG, KARL. Kleinasiens Naturschätze, seine wichtigsten tiere, Kulturpflanzen und Mineralschätze. Berlin: Gebrüder Borntraeger. 1897. *M.* 14.

[3] CHRIST, H.—Die Farnkräuter der Erde. 8vo. pp. xi + 388. *figs. 292.* Jena: Gustav Fischer. 1897. *M.* 12.

Another principle in the selection of species has been to include those which are remarkable in structure, phylogenetic character, or biological peculiarity. Those genera which, as he says, "are weakly expressed, showing only one or a few disappearing species," he omits in favor of those which are rich in species and uniform in character. He also omits peculiar island types, such as those of the Sandwich islands, Madagascar, etc.; nor does he include the rich fern flora of the Andes. His contention is that a comprehensive monograph, with a critical catalogue of all species, would be a work of several volumes, and would not serve the general purpose he has in view. With all these restrictions he presents 99 genera and 1154 species.

No analytic keys are provided, but simple descriptions of genera, sections, and species are depended upon to guide sufficiently. The author claims that a safe key is only possible for a limited flora and small genera and that the more inclusive the key the more unsafe does it become. The descriptions are exceedingly simple, technical terminology being avoided so far as possible.

An excellent feature of the book is to be found in the numerous illustrations in the text accompanying the descriptions. These illustrations show at a glance the characters described by the text. It would be a useful thing if American students of ferns had a translation of this handy and simple volume.—J. M. C.

Text-book of lichenology.[4]

It is so long since any work on lichens has been published by an American author that we take up Dr. Schneider's book with especial interest. In the preface we find this statement: "This work is primarily intended as a text-book for the use of students in colleges and universities, but will also be found useful to the specialist." Our secretly cherished hope that the study of lichens is to be popularized begins to fade away when we read that statement. As we glance over the technical treatment outlined for the subject, the hope entirely disappears. The book will be useful to those for whom it was written, but a feeling of regret will arise that it was not adapted for more general use. The plates, of which there are seventy-eight, add greatly to the value of the book, though it must be said that they are somewhat schematic. The subject-matter is divided into two parts. Part I treats of the history, general morphology and physiology of lichens; Part II of the classification and special morphology of lichens.

The first subject treated is the history of lichenology. This is stated to is in the main "a condensed retrospect of Krempelhuber's *Geschichte der Lichenologie*," Krempelhuber's book bearing the date of March 1886. Dr. Schneider adds two periods to bring the history up to date: one from Schwendener (1886) to Reinke (1894), the other from Reinke (1894) to the close of 1896. Dr. Schneider admits that Reinke's propositions have not generally been accepted as correct, but maintains that they "are based upon sound argument and should, therefore, mark the beginning of the period in which lichens are recognized as a distinct class of plants; such recognition being based upon physiological considerations."

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[4] SCHNEIDER, ALBERT.—A text-book of general lichenology. Large 8vo. pp. 230, 76 plates. Binghamton, N. Y.: Willard N. Clute & Company. 1897.

The second chapter is devoted to symbiosis. The subject is divided into antagonistic symbiosis (parasitism), nutricism, and mutualistic symbiosis. Under the latter mutualism and individualism are distinguished, the former characterized by the fact that the symbionts are not wholly dependent upon each other for their existence, while in the latter form at least one of the symbionts is absolutely dependent upon the symbiotic association. The phenomenon of individualism is typically met with in lichens, according to Dr. Schneider, and really forms the basis for Reinke's claim that they should be considered a distinct class of plants. Then follows an interesting discussion of the thallus and apothecium, the structure and function of their different parts, their method of growth, mechanical adaptations, etc.

In the consideration of the reproduction and propagation of lichens, Dr. Schneider contends that the spores are unreliable aids to reproduction, and play only an insignificant part in the maintenance of species, because the spore upon germination may not find the proper symbiont alga and also because in some species the spores are only rarely developed. It is doubtful if this view of the subject will find full acceptance.

The next chapter is devoted to the polyphylogeny of lichens. Five families of fungi are given as probable ancestral groups of fungal symbionts, though the statement is made that it is impossible to study out the ancestral fungal types at present. Nine genera of algæ are given which are known to enter into symbiotic relationship to form lichens.

The system of classification proposed is then discussed. Dr. Schneider begins by the statement that "there is at present no satisfactory natural or artificial system," and then proposes an arrangement into orders, families, genera, and species without further subdivision. One who has worked much with lichens cannot but wonder what he proposes to do with the varieties and subvarieties recognized by all systematic writers on lichens. Will the number of species be indefinitely multiplied or shall we find the description of the species so broad that all the varietal forms may be easily accommodated? Judging from the number of genera recognized the first supposition would be the correct one. The orders recognized are the Ascolichenes, Basidiolichenes and Gasterolichenes, based on the method of spore formation.

As family characters, the probable fungal ancestors, the structure and development of the apothecium and thallus are suggested, with some reference to the spores and algæ. In view of the earlier statement that it is impossible "to study out the ancestral fungal types at present," the use of these fungal types as a basis of classification must be difficult. As generic characters the spore characters are given as of primary importance; then the development of the thallus, the apothecium, the exciple, the color of the apothecial disk, the algæ, and the color of the thallus. A number of genera are based upon algal differences. As to specific characters our author says "in general it may be stated that in the establishment of species all known characters must be considered more or less." Chemical reaction is considered of no importance in distinguishing species.

One turns with considerable interest to Dr. Schneider's application of his principles of classification, and it is inevitable that one should compare his work with the classic work of Professor Tuckerman in the same field. Thirty-four years elapsed between the publication of Professor Tuckerman's *Synopsis* of the Lichens of New England, the other northern states and British America, and his publication of his *Synopsis of the North American Lichens*. During all that time he was occupied more or less exclusively with the study of lichens, so we may be assured that his *Synopsis* represents his mature judgment. His *Synopsis* covers the whole of North America; Dr. Schneider's *Text-book*, the northeastern United States. We find seventy-[illegible] genera in Professor Tuckerman's *Synopsis*, while Dr. Schneider recognizes seventy-seven genera. If we deduct the thirteen genera recognized by Professor Tuckerman of which no species are recorded as occurring in the region covered by Dr. Schneider, and the eleven genera recognized by Professor Tuckerman as occurring in that region but of which Dr. Schneider makes no mention, we can better appreciate how the Tuckerman genera have been divided up.

But what of the twenty-six new genera thus established? Some are recognized by Professor Tuckerman as sections under his genera, some as distinct genera by other lichenologists, but many are established on a very slight basis, as for instance *Mallotium*, of which Dr. Schneider says "the essential character which distinguishes this genus from Leptogium is the presence of numerous long, comparatively rigid, gray rhizoids which extend in clusters from the lower surface of the thallus." When the great variability in the development of rhizoids is considered, one is startled to see them made the basis of a genus. Is this so much more scientific than Professor Tuckerman's work, of which our author says "he also issued a work on the genera of lichens and their relationships, which is, however, unsatisfactory because the author did not seem to have any clear conception of genera."

While recognizing the careful work that Dr. Schneider has done, we cannot but regret that he has complicated still further the study of lichens by the proposal of a new system of classification.—CLARA E. CUMMINGS.

A notable host index.

WHAT DeCandolle's *Prodromus* did for the systematic study of spermatophytes, Saccardo's *Sylloge* has done for the study of fungi. In the eleven [illegible] volumes of this work all species of fungi described before 1895, over [illegible]-two thousand, have been displayed, with synonyms and geographical distribution. In 1897 an index to genera and species, prepared by Dr. Sydow, was issued, forming volume twelve of the work. And now we have the first part of volume thirteen,[5] compiled by the same bibliographer, indexing the work by hosts. The typographical features of the volume are of the best. The name of the host is printed in bold-faced type, and the names of the attendant fungi are given beneath in a single column. The clearness and the simplicity of the arrangement leave nothing to be desired. By the issuing of this volume the mycologists of the world are placed under a further debt of gratitude to the promoter of the work.— J. C. A.

Fundamental problems of science.[6]

THIS BOOK is an attack upon the theory of so-called scientific materialism, written by a disciple of Schopenhauer. The indictment contains two counts: first, that the theory in question attempts to explain all the phenomena in the world, open to scientific investigation, by means of motion; secondly, that it assumes the reality of matter as an extended impenetrable substance existing independently of our perceptions, and conceives of it as the main, if not the sole, constituent of the universe. In his criticism of the second of these two propositions Dr. Wagner is at one, not merely with practically all students of philosophy, but also with many, perhaps the majority of the scientists of today. Even the drudge, whose ideas never rise above the label-pasting, has had the problem of the real nature of matter forced upon his attention by the writings of Huxley in England, and Helmholz in Germany — to mention only two of the most eminent. Indeed, it requires but a moderate amount of meditation to discover that one's own consciousness is the sole source of knowledge, and that therefore the only direct information as to the nature of the constituents of the external world is given by sensation. The coming and going of these sensations reveal the existence of [illegible] forces, or perhaps a single force, to whose activity they are due, but [illegible] we can jump out of our own skins we can have no idea of the nature of these forces as they are in themselves. Annihilate the conscious subject, and extension and impenetrability — the qualities of touch — disappear along with color and odor, gone perhaps to look for the hole in the cookie after the cookie has been eaten.

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[5] SACCARDO, P. A.— Sylloge fungorum omnium hucusque cognitorum. Vol. [illegible] Index universalis et locupletissimus hospitum fungorum. Auctore P. Sydow. [illegible] [part I, pp. 1–624.] Berolini: Fratres Borntraeger. 1898.

[6] WAGNER, ADOLF.—Grundprobleme der Naturwissenschaft. Briefe eines [illegible]en Naturforschers. 8vo. pp. viii + 255. [No index.] Berlin: Gebrüder Borntraeger. 1897. *M* 5.

From these premises Dr. Wagner considers himself entitled to conclude that the atom and the ether are pure mythological entities. But here he certainly moves too fast. That the atom does not exist in the sense in which materialism supposes it does may well be conceded, but, though essentially intangible and invisible, the question whether it may not exist in the same sense in which the flower that is "born to blush unseen" may be said to be a reality, is another problem — one to be decided by a study of evidence which lies entirely outside of the province of the metaphysician as such to discuss. As well might he have dogmatized about the formation of crystals from solutions before Leuwenhoek turned his microscope upon them, or about the cause of tuberculosis while Koch was still experimenting with staining fluids.

In our use of the word "cause" we have laid ourselves open to another criticism which our author directs against the atomic theory. The only efficient causes, he tells us, are the forces that lie behind phenomena; and, therefore, to talk of the atom or the ether as active agents in the production of change is an absurdity. In one sense this is true enough, but as a criticism upon the use of these terms by a scientist who knows his business, it is irrelevant. The invisible water in the form of steam, in the cylinder of the engine, is just as truly an agent capable of doing work as is the visible water that turns a mill wheel. Perhaps in all strictness we ought to speak rather of the unknown forces that lie behind the steam, as the true agent; if so we must revise in a corresponding manner our everyday language about the mill stream.

It will be seen that Dr. Wagner's book, clearly and convincingly as it has stated some fundamental truths, is a horrible example of the confusion of the scientific and the metaphysical problems raised by the world of nature. But he is not the first. His immediate predecessor in this line is the illustrious Professor Ostwald, who seems to think he has found in idealism a weapon with which to destroy a theory which he himself has probably rejected on other grounds. And then there are the "scientific materialists." Mistaking the atom for a metaphysical entity they suppose themselves in possession of the clue to the nature of ultimate reality. Reviling all metaphysics, they themselves have swallowed whole one of the shallowest and most dogmatic of metaphysical systems — a spectacle which would certainly be one of the most amusing in the history of thought, if it were not at the same time one of the most mournful.—FRANK CHAPMAN SHARP.

Lessons with plants.

ANOTHER BOOK comes to us from the pen of Professor L. H. Bailey, which is likely to be highly acceptable to the constituency to which it is essed. It is not "a botany," as announcements had led us to expect, as its title page informs us, a book of "suggestions for seeing and interting some of the common forms of vegetation."[7] Those who have seen teachers' leaflets for nature study, which are being issued under Professor ley's direction by Cornell University, have already a fair sample of what book is in its spirit; indeed, some of these leaflets reappear in the book only slight adaptation. Perhaps it will not be too much to say that this k is part of Professor Bailey's crusade against the formal dry-as-dust ching of botany, in which every live teacher wishes him God-speed.

The methods which are suggested to teacher and pupil herein are the per ones, beyond question; there are no others which can be called teach-. The preface at least we would have every teacher read and ponder; it ch in pedagogical suggestions, not so new, perhaps, as forceful. The gram there laid down is executed in the following pages in most admi- fashion, where, by suggestive questions and hints, the user is led to interpretations of many familiar objects in the plant world. Accom-ing these interpretations are paragraphs in smaller type containing rmation upon the more formal aspects of the subjects studied; which ds the author into the statement that, as a last resort, "the pupil may te from the book, for enough of formal statement and definition may have t into the work to enable it to be used as a simple text-book." But its n purpose is to suggest methods of nature study, "and since the author t bring the plants with him he brings good pictures, which are the next st things." These are indeed admirable; fresh, accurate, and rendered h a high degree of artistic feeling. Professor Holdsworth may well be ked with Sprague and Faxon as a botanical artist of the first quality. y once, as far as we see in this book, has he failed to interpret in lines at he has seen; figure 321 is quite inaccurate.

It seems almost captious to say anything in unfavorable criticism of a k in which so much is excellent. It is because the methods suggested are good that we wish there had been more about the neglected lower plants ch are quite as common as the flowering ones which the author uses. e, two lessons are devoted to the cryptogams. But will youngsters be less interested in the green scums, the gray lichens, the matted mosses, curious puffballs, than in diclinous flowers, to which three lessons are en? Are not these just as common as the commonest seed plant? And not the formal statement and definition, which might creep in about se, keep things balanced a little better than to encourage the idea that the flower is the important organ, that seed plants are the *real* plants, and ferns, mosses, and toadstools very much of a side issue?

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[7] BAILEY, L. H.—Lessons with plants; suggestions for seeing and interpreting of the common forms of vegetation; with delineations from nature by W. Holdsworth, assistant professor of drawing in the Agricultural College of igan. 12mo. pp. xxxii + 491. *figs. 446.* New York: The Macmillan Co. 1898.

And then we *do* wish that the pernicious comparison of spores and seeds had not been perpetuated. If Professor Bailey had been condemned for ten years to eradicate from elementary pupils' minds the idea that a seed when it germinates produces a new plant, and to inculcate a true idea of the relation between seed and spore, he would thoroughly appreciate this desire.—C. R. B.

An organography of the higher plants.

A WELCOME BOOK is the recently published treatise on the general organography of plants by Professor Dr. Goebel of Munich.[8] No one who has given attention to the shifting of the point of view of progressive morphologists can fail to observe that the problems in this field are now seen in an entirely new light. No longer is there presented to the student the conception of an ideal leaf or flower, from which, as from a "pattern," those he observes show "deviations" more or less marked, for which no conceivable reason is assigned except the production of "variety in nature." On the contrary, he is set to study the forms of organs as they exist and to seek in external and internal conditions as they influence hereditary "tendencies" (alas, our ignorance!) the efficient causes for the forms he observes. The old idealistic theory of metamorphosis is giving ground to more realistic views of development as we become able to get closer to the plant. It is plain that modern morphology must base itself upon physiology and ecology.

But these exacter views are as yet in their formative stage, and many who are not specialists are scarcely aware of the departure in current literature from the older standpoint. To these, and to the specialist as well, the gathering together of these newer ideas into a compact discussion will be of great service. The present volume is only the first, or general part, to be followed presumably by a second, treating of special morphology, a work which we hope will not be long delayed, spite of the fragmentary character of the available materials. In order to show the nature of the general part we here translate the principal headings:

Section I. The general segmentation of the plant body: morphology and organography, classification of the organs of seed plants, formation of organs and division of labor among lower plants (thallophytes), normal formation of organs at the growing point and regeneration, coalescence (*Verwachsung*) and dwarfing. *Section II.* Symmetry: positions of organs on radial axes, dorsiventral shoots, symmetry of leaves, symmetry of flowers and inflorescences. *Section III.* Differences in the formation of organs at different stages development; young forms. *Section IV.* Malformations and their significance for organography: how malformations arise, significance of malformations for the theory of formation of organs. *Section V.* Influence of correlations and external stimuli upon form.

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[8] GOEBEL, K.—Organographie der Pflanzen, insbesondere der Archegoniaten und Samenpflanzen. Erster Teil: Allgemeine Organographie. 8vo. pp. x+232. *figs. 130.* Jena: Gustav Fischer. 1898. *M.* 6.

These topics are treated in a clear and concise manner, in German which is a pleasure to read. If any parts be selected as instructive above others, they would be, in our judgment, the fourth and fifth sections, in which the author discusses the relation of teratology to organography and the formative influence of external stimuli.

In the former, after pointing out the impossibility of an exact definition of abnormalities as distinguished from variations, he shows that monstrosities are not lawless, since the fundament (*Anlage*) of a shoot is never misdeveloped into a leaf or root, nor a sporangial fundament into a vegetative organ. For when stamens or carpels are malformed, it is always the nutritive parts which are developed, while the sporangia are dwarfed. Such structures are not reversionary in the least, but are due to pathological disturbances, and cannot lead to any correct phylogenetic conclusions. Malformations in general, Goebel holds, are either inherited (of which he cites numerous examples), their development at any particular time, however, being often coupled with the action of external conditions, in whose absence they persist as latent fundaments; or the external factors are the causal impetus of malformations, especially in the lower plants, though examples among seed plants are not wanting. The study of monstrosities leads to the conclusion that Sachs' theory of “Stoff und Form” is the most satisfactory one, *i. e.*, that differences in the forms of organs are due to differences in the plastic materials.

In discussing correlations the author points out two general categories: one, which he calls quantitative correlation, depends on the competition between the fundaments of different organs, which determines the extent of development of the organ; the other, qualitative, influences direction of growth and the form of organs such as thorns, sporophylls, bud scales, and tendrils. In discussing the influence of external stimuli many interesting effects of gravity, light, medium, and mechanical stimuli are cited, of which no outline would convey an idea.

In any attempt to get out of a rut, the very effort is likely to carry one beyond the middle of the road. To this we must ascribe Goebel's objection to the use of the term “leaf fundament” (*Blattanlage*) on the ground that, as the idea “leaf” is a mere abstraction, there can be no such thing as a leaf fundament, but only fundaments of foliage leaves, scale leaves, etc. In support of this general position he argues that if the theory of metamorphosis had started with the examination of roots instead of leaves, it would not have been led into such vagaries, or have generalized the concept “root” until nothing remained but an abstraction. Botanists would have more clearly recognized that function determines form. But however clearly we recognize now this fact, and however improved become our views of morphology in consequence, it is improbable that categories of homologous organs will cease to demand recognition in our thought and in our terminology.

In a somewhat similar way the author constructs men of straw out of the categories caulome, trichome, etc., and charges them so impetuously that his momentum carries him beyond safe middle ground to untenable positions. So completely has he taken the physiological point of view, that he prefers to base terminology upon analogy, even when he acknowledges that it obscures homologies. This may do for popular speech, but it ought not to continue and cannot long persist in scientific language.

Though every reader may not be able to go the full length with Professor Goebel, it is manifest that he has produced a most useful and stimulating treatise on the organography of plants, which no one who cares to keep abreast of modern views can neglect.—C. R. B.

MINOR NOTICES.

DR. CHARLES F. MILLSPAUGH[9] has published a third contribution to the knowledge of the flora of Yucatan. The Schott herbarium recently obtained, the Witmer Stone collection of 1890 under the auspices of the Academy of Natural Sciences of Philadelphia, the E. P. Johnson collection of [illegible] (examined at the herbarium of Columbia University), and the continued collections of Dr. Geo. F. Gaumer, have furnished much material not reported heretofore. Sixteen new species are described.—J. M. C.

TWO USEFUL bibliographical works have recently reached us. One is from the U. S. Department of Agriculture; a library bulletin containing a "Reference list of publications relating to edible and poisonous mushrooms." It has been compiled by Miss Josephine A. Clark, the assistant librarian, to whom botanists are already under obligations for her card index of new species and illustrations. This bulletin seems to have been called out by the of poisoning some prominent persons at Washington lately through eating amanitas. The list contains 306 titles.

The other bibliography is a list of periodicals relating to botany in the New York public library and the library of Columbia University, and also a list of those relating to horticulture and gardening in the same libraries. This 11-page pamphlet reaches us "with the compliments of Lucien M. Underwood," but bears neither imprint nor indication of who its compiler may be. This, however, will not interfere with its usefulness—.C. R. B.

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[9] Contribution III to the coastal and plain flora of Yucatan. Field Columbian Museum Publication 25. Botanical Series 1:345-410. 1898.

THE BOOKLET, *Flowers that never fade*,[10] contains an account of the Ware collection of Blaschka glass models in the Harvard University museum. The description was originally prepared by Mr. F. B. Wiley, the author of the *Harvard Guide Book*, for the Boston *Transcript*, in response to requests for information concerning this unique collection. Revised and considerably extended, it is now reprinted, with a poetic (?) introduction. Fulsome praise vies with the description of the inception and execution of the work, and of

"The home at Hosterwitz,
Where a lonely artist sits."

The author warmly congratulates Harvard University on being "the fortunate possessor of the only collection of these exquisite creations now in existence," and about them he sings:

"The varying seasons bring
No change to this blossoming:
The spring never ends for these
Enduring anemones;
The summer's reign never closes
For these perennial roses:
The autumn's horn never holds
Even one of these marigolds;
And the winter never comes
To these bright chrysanthemums."

Mum's the word.—C. R. B.

A USEFUL SET of directions for experiments in plant physiology has recently been published by Dr. J. C. Arthur, in pamphlet form.[11] The series includes thirty-five experiments, and are those which he has found serviceable in illustrating a course of lectures extending over five months. The directions are intended only as a guide to manipulation; not to indicate the purpose of the experiment or the deductions from it. The experiments chosen are illustrative of the fundamental processes of plant life, and the pamphlet will be particularly valuable to teachers who are conducting elementary college courses.—C. R. B.

THE INTEREST in native edible mushrooms, and *per contra* native poisonous ones, has been increasing for sometime. Every addition to the literature of the subject is likely to find an expectant public. The recent publication by

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[10] WILEY, FRANKLIN BALDWIN.—Flowers that never fade: an account of the Ware collection of Blaschka glass models in the Harvard University museum. 16mo. pp. 47. Boston: Bradlee Whidden. 1897. 35 cents.

[11] ARTHUR, J. C.—Laboratory exercises in vegetable physiology. 8vo. pp. 32. figs. 5. Lafayette, Ind.: Kimmel & Herbert. 1897. 35 cents.

Dr. Thomas Taylor[12] of a work on mushrooms, with colored plates of reasonably good quality, will doubtless meet with an appreciative response. Dr. Taylor was for many years the microscopist of the United States Department of Agriculture, and the readers of this journal do not need to be told the character of his work. In this official capacity he issued a number of reports on mushrooms, which have furnished some of the material for the present series.

Although the subject is not treated in a sufficiently systematic way properly to entitle the work to the name of "handbook," and in spite of some irrelevant matter, the mycophagist will yet find much in these pages to help him.— J. C. A.

NOTES FOR STUDENTS.

A NEW Rumex from Colorado has been described by Geo. E. Osterhout[13]—Further notes on the southern species of Asarum have been published by W. W. Ashe.[14]— Professor E. L. Greene[15] has published another fascicle of "New or noteworthy species," in which the following genera are represented by new species: Delphinium, Myosurus, Viola, Mertensia, Plagiobothrys, Lithospermum, and Eriogonum. In "Studies in Compositæ" some helenioid genera are taken up. The name Actinella, as employed by Nuttall and by Gray, is a homonym, and Rafinesque's Ptilepida (used in the *Check List*) is precluded as a synonym of Persoon's Actinella and not of Nuttall's. Accordingly Professor Greene publishes the name *Tetraneuris*, under which he places eighteen species. Hooker's Picradenia is kept separate from it, and a new genus, *Rydbergia*, is founded on *Actinella grandiflora* T. & G.—Those wishing to keep pace with the synonymy of the species of Asarum should not fail to note the recent brief paper by James Britten and Edward G. Baker, who introduce the new name *A. Shuttleworthii.*[16]—J. M. C.

HERMANN VON SCHRENK'S[17] study of the influence of the tornado of 1896 upon the trees of St. Louis is an important contribution to the general subject of the effect of extraordinary conditions upon plant life. Mr. von Schrenk's observations of the striking phenomena he describes are extensive and valuable. Finding the immense destruction of leaves to have been the most serious damage done by the storm, he points out the disastrous results of the stoppage of the transpiration current and of the manufacture of nutritive products at a time when the uninjured roots were at a period of their greatest absorbing activity. Where the deficiency in leaf exposure was partially made up either by adventitious budding or by premature growth from the leaf axils of the undestroyed twigs of 1896, careful observations were made of the unnatural "growth ring" thus established. This ring, very evident in the surviving twigs, easily traceable in the larger branches of several years formation, was not to be observed in the main trunk. In very many cases, even where the normal functions seemed to have been restored, trees have since died on account of injuries received by the bark, either by violent wrenching or by later intensified insolation. In the latter case, when the temperature between wood and bark must have risen to a height which destroyed the delicate cambium, the bark has since peeled off before the vegetative parts of the tree have shown signs of withering. Such bark-scorching was almost universal, and Mr. von Schrenk predicts that many of the finest trees for this reason will be unable to stand the strain of another summer. Six plates amply illustrate the text.—J. G. COULTER.

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[12] TAYLOR THOMAS.— Student's handbook of mushrooms of America, edible and poisonous. Washington, A. R. Taylor (238 Mass. Ave., N. E.). 8vo. In five numbers of twenty-four pages, and five or six partly colored plates each. 1897–8. [illegible] cents per number.

[13] Erythea **6**: 13. 1898.

[14] Jour. of the Elisha Mitchell Soc. **14**: 31–36. 1897.

[15] Pittonia **3**: 257–272. 1898.

[16] Jour. Bot. **36**: 96–99. 1898.

[17] The trees of St. Louis as influenced by the tornado of 1896. Trans. St. Louis Acad. Sci. **7**: 25–41. 1897.

F. HEGELMAIER [18] has made an interesting contribution to the subject of polyembryony. In *Allium odorum* he finds embryos developing not only in the normal manner, but also from synergids, antipodals, and from the wall of the inner integument. One embryo sac contained five embryos, one normal, another from a synergid, two from antipodal cells, and still another from the inner integument. Many irregularities were noted both in the suspensor and in the embryo proper. The stock from which the material was taken had been cultivated in gardens for over twenty years.—CHAS. J. CHAMBERLAIN.

A SOMEWHAT MISCELLANEOUS summary of late embryological work is given in the *Rev. Gen. Bot.* of June 1897. The contributions reviewed range from the work of Chauveaud [19] upon polyembryony among the Asclepiadeae to Belajeff's well known study of the phenomena of the pollen tube in Gymnosperms,[20] and Guignard's *Nouvelles études sur la fécondation.*[21] It is too incomplete to be taken for a bibliography of even the most critical recent contributions in this field, but does offer an easy way of getting at the gist of several valuable but verbose contributions. In the issue of October 15 M. Prunet gives a clear presentation of the embryological investigations [illegible] Jaccard[22] on Ephedra and of Karsten[23] on Gnetum.—J. G. COULTER.

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[18] F. HEGELMAIER.—Zur Kenntniss der Polyembryonie von Allium odorum. Bot. Zeit. 55: 133–140. 1897.

[19] Sur la fécondation dans les cas de polyembryonie. Reproduction chez le Tomp-venin. Paris, Soc. d'edit. sci., 1892.

[20] Zur Lehre von dem Pollenschlauche der Gymnospermen. Ber. der deutsch. bot. Gesell. 11: 196–201. 1893.

[21] Ann. des Sci. Nat. VII. 14: —. 1891.

BY PLACING etiolated leaves, from which the carbohydrate substances have been as completely removed as possible, in contact with various solutions, M. W. Palladine[24] has demonstrated the beneficent influences [illegible] certain substances upon the formation of chlorophyll and the retarding effect of others. He lists among substances favorable to chlorophyll formation saccharose, raffinose, glucose, fructose, maltose, glycerin, galactose, lactose, and dextrin. Inuline and tyrosine have no perceptible effect under the conditions employed, while contact with mannite, dulcite, asparagin, urea, alchohol, chloride of ammonia, and quinic acid either checks or absolutely prevents its formation. He also demonstrates by a very simple and efficient experiment that respiration proceeds freely in an atmosphere impoverished of oxygen, in which chlorophyll appears in etiolated leaves [illegible] at all or only very slowly.—J. G. COULTER.

RECENT ANNUAL REPORTS from the experiment stations containing botanical information are as follows: The Rhode Island report for 1896 treats of carnation diseases (pp. 203–210) by L. F. Kinney, especially of fairy-ring, rust, and "petrified" buds. The two first mentioned were effectively checked with Bordeaux mixture and removal of diseased leaves; the last is supposed to be due to forcing growth beyond healthful limits, as the buds never open. One-third of the report (pp. 242–318) is devoted to an illustrated account of the extended studies of H. J. Wheeler and G. M. Tucker on the value of [illegible] as a fertilizer for field crops. Beneficial results were obtained with many kinds of plants and at different localities in the state. It is ascribed, after making pot observations, to the corrective action upon soil acidity.

The report of the Vermont station for 1896–7 contains observations upon pollination of the plum (pp. 87–98) by F. A. Waugh, embracing many interesting details; and also some account of the action of enzyms in hastening germination (pp. 106–111), by the same investigator. The botanist of the station, L. R. Jones, writes (pp. 44–74) upon early blight of potato, including a full bibliography of *Alternaria Solani*, upon the effect of disinfectants [illegible] ve sublimate and formalin) on early growth of potatoes, upon apple scald, smut, and onion mildew, and upon the orange hawkweed (*Hieracium rantiacum* L.), for which salt applied dry at the rate of about 3000 pounds acre is found to be an effective exterminator. All the topics include many new and important observations.

---

[22] Recersches embryologiques sur l'Ephedra helvetica. Bul. de la Soc. Va des Sc. nat. 30: —. 1894.

[23] Beitrag zur Entwickelungsgeschichte einiger Gnetum-Arten. Bot. Zeit. 50: —. 1892.

[24] Recherches sur la formation de la chlorophylle dans les plantes. Rev. gen. de bot. 9: 385–394. 1897.

The report of the botanist of the New Jersey station, Byron D. Halsted, been distributed as a separate in advance of the full report for the year It is probably the largest report (pp. 261–394) made by any of the n botanists, and records a great number of observations, mostly relat- to plant diseases and fungicides. The turnip, cabbage, potato, pep- tomato, bean, onion, spinach, egg plant, clover, cucumber, pea, carrot, beet, sweet potato, asparagus, pear, violet, hollyhock, and many other vated plants have received attention. Beside pathological studies, eriments were made in shading plants with lath screens, advantageously ase of lettuce, spinach, Swiss chard, celery, and bush beans, and injuri- in other cases. The report is illustrated with thirty-two cuts, all half- es from photographs, and nearly all most wretchedly printed. It seems as reasonable to print illustrations so badly that nothing can be made out of as it would be to print the text in a blurred and unreadable condition.— C. A.

NEWS.

Dr. Eduard Zacharias has been called to the directorate of the botanical garden at Hamburg.

The knight's cross of the Austrian Order of Leopold has been conferred upon Professor Dr. Julius Wiesner.

Mr. J. G. Luchman has been appointed Government Botanist of Victoria, the post so ably filled for many years by the late Baron Ferdinand von Mueller.

Professor L. H. Bailey, of Cornell University, sailed for Europe last month. The length of his stay remains uncertain. He is stopping at present in Munich.

From *Science* we learn that Messrs. A. & C. Black will publish the lectures given by Dr. D. H. Scott at University College, London, last year, under the title of "Studies in fossil botany."

Professor Alfred J. McClatchie, formerly of the Throop Polytechnic Institute, Pasadena, Cal., has been appointed professor of Agriculture and Horticulture in the University of Arizona, at Phoenix.

Dr. Rudolf A. Philippi, for many years director of the National Museum of Santiago, Chili, has been obliged to retire from the duties of this post by reason of advancing years. He is now in his ninetieth year.

The current numbers (169 and 170) of *Die natürlichen Pflanzenfamilien* are devoted to a continuation of the Musci, by Carl Müller, and the Dacryomycetineæ, Exobasidiineæ, and Hymenomycetineæ, by P. Hennings.

Dr. D. S. Johnson, Instructor at Johns Hopkins University, will have charge of the botany at Cold Spring Harbor during next summer. Work is offered in "cryptogamic botany," "phænogamic botany," and "bacteriology."

Professor John Macoun has published in the *Ottawa Naturalist* (11: 193–204. 1898) the third part of his "Cryptogamic Flora of Ottawa." It contains a continuation of the mosses, which cover some 220 numbers, and also the liverworts, 30 in number.

An address on "The province and problems of plant physiology," by Professor D. T. MacDougal, is published in *Science* (7: 369–374. 1898). It is a clear and pungent statement concerning a field of work persistently misunderstood, even by teachers of botany.

Dr. J. C. Arthur's paper on "The movement of protoplasm in cœnocytic hyphæ," read before the Botanical Society of America at its Toronto meeting and briefly outlined in this journal (**11** : 181. 1897), has been published in the *Annals of Botany* (**24** : 491–507. 1897).

Purdue University is publishing a series of leaflets on Nature Study. The botanical subjects thus far presented are "the foliage leaf," "the flower," "trees," and "a country school garden," by Professor Stanley Coulter. L. H. Bailey's "a children's garden" is also reprinted as one of the leaflets.

Mr. James Britten has published (*Jour. Bot.* **36** : 90–94. 1898) an interesting discussion upon the fifty years' limit in nomenclature, proposed by the so-called Berlin rules. There seems to be no question that the rule, even if deemed desirable, would be impossible of application, involving as it does such indefinite requirements as "general use," "monograph," etc.

Mr. Clifton D. Howe, of Burlington, Vt., very much desires to know the location of C. C. Frost's collection of liverworts. In connection with Professor L. R. Jones he is making a study of the Vermont Hepaticæ, and expected to be aided by the Frost collection. Not a single specimen has been found in the Frost herbarium, or those of Amherst, Harvard, or Columbia and no one as yet has been able to give any clue as to the possible whereabouts of Frost's specimens.

A memorial sheet has been issued in honor of the late Baron Sir Ferdinand von Mueller. In it we note that the supplemental volume of the *Flora Australiensis*, which was in preparation for the press at the time of his death, is to be published; also two volumes on his administration as director of the Botanical Garden, comprising a biography and a complete bibliography. The executors are now making an effort to erect over the grave a suitable monument, and are asking subscriptions for this purpose.

An announcement from the Herbarium of the Field Columbian Museum gives the information that during the last two years over 50,000 sheets have been accumulated, well scattered throughout the world, 16,000 of which are from North America. A detailed list indicates the states and collectors chiefly represented. The present arrangement of the herbarium is alphabetical by genera, the American genera in manilla covers, the European in green, the African in blue, the Asiatic in red, and the Oceanican in yellow.

The New England Botanical Club has published its constitution and a list of officers and members. The officers are George Lincoln Goodale, president; Joseph Richmond Churchill, vice president; Edward Lothrop Rand, corresponding secretary; Emile Francis Williams, recording secretary and treasurer; Walter Deane, phænogamic curator; George Golding

Kennedy, cryptogamic curator. The club meets the first Friday of each month, excepting the summer months; and the herbarium is kept in the Harvard University Museum. The address of the secretary, Mr. Rand is 740 Exchange Building, Boston.

WITH THE FIRST number of the fourth volume *The Forester* passes into the ownership of the American Forestry Association, which will publish it as the organ of the association. The only information as to its editorial management is the following from the proceedings of the association: "The new journal is to be *The Forester*, being the paper heretofore published by Mr. John Gifford, of Princeton, N. J., which he has conveyed to the association. A newspaper correspondent has been secured as managing editor, assisted by a committee of the association, with Dr. Fernow as chairman." This number (of 24 pages) is devoted to the white pine situation.

THE *Annals of Botany* has published as a sort of preface to Volume XI., completed with the number for December 1897, a biographical sketch and portrait of Professor M. J. Berkeley. The sketch is prepared by Dr. Thiselton-Dyer. Berkeley is said to have been the virtual founder of British mycology, his work in this field having begun in 1836, when he undertook for Sir William Hooker the description of the British species. It is stated that he has probably published descriptions of some 6000 species, with a skill and precision which has made this enormous work durable. In 1846 he began his study of diseases of plants, and is said to have been the first to attack the subject in a systematic manner. In 1857 he published his well-known *Introduction to Cryptogamic Botany*, which was the first comprehensive treatise of this kind in any language.

THE FIRST NUMBER of *Pharmaceutical Archives* has come to our table. It contains a paper on the "Comparative structure of the leaves of *Datura Stramonium*, *Atropa Belladonna*, and *Hyoscyamus niger*," by J. O. Schlotterbeck and A. Van Zwaluwenburg; "Structure of the twigs of *Fraxinus Americana*, by R. H. Denniston, each illustrated by two plates; a continuation of Peckolt's "Folk-names of Brazilian plants and their products," and a continuation of Brown's "Chemical bibliography of morphine 1875-1896" from the *Pharmaceutical Review*. The new journal promises to have in it much material of value to botanists and bespeaks their support. Some details of style and typography have escaped the control of the editor in this number which will be corrected in the next issue. The plates, printed on both sides, are to be reprinted in proper form. The editor is Dr. Edward Kremers, of the University of Wisconsin.

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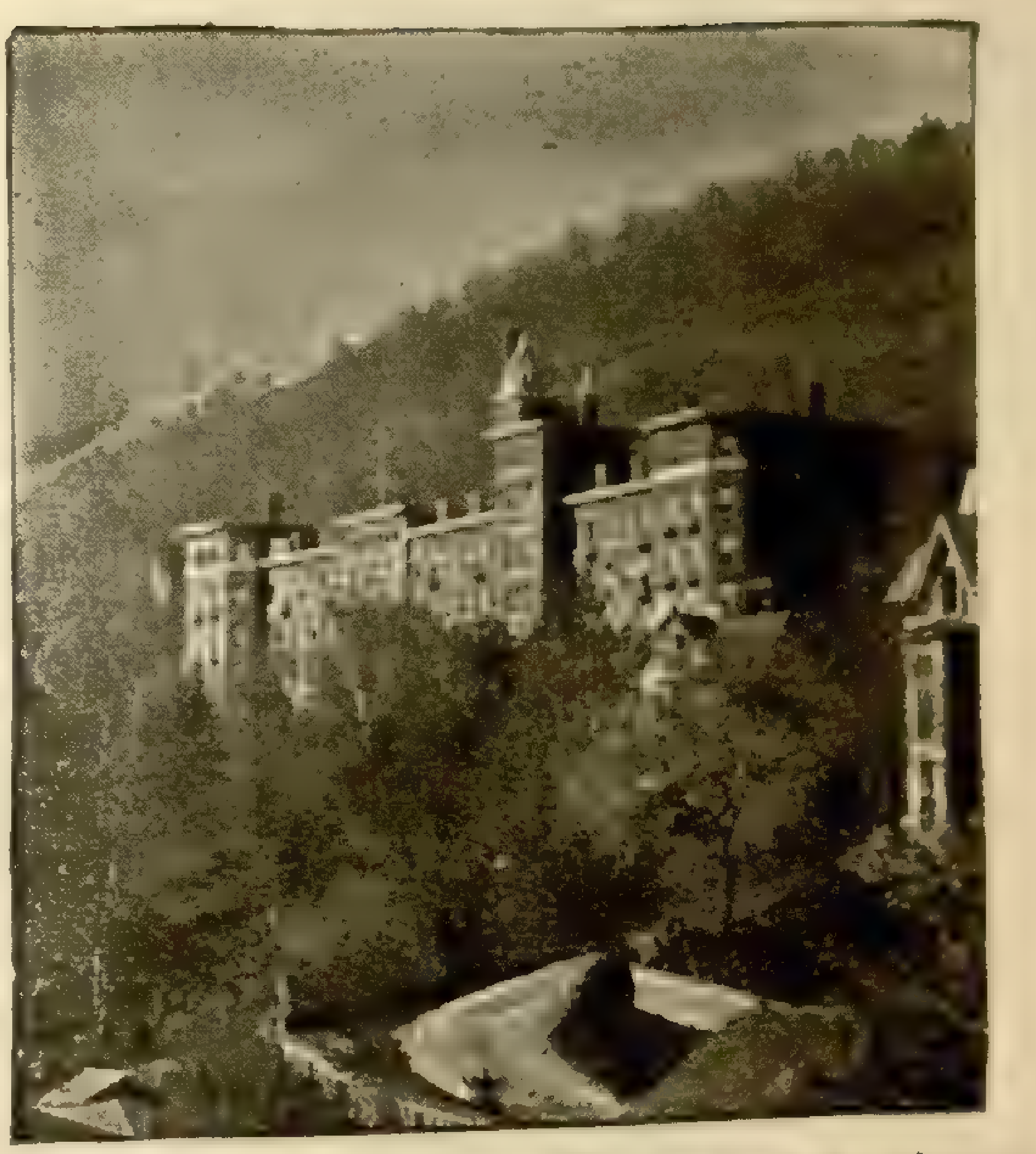

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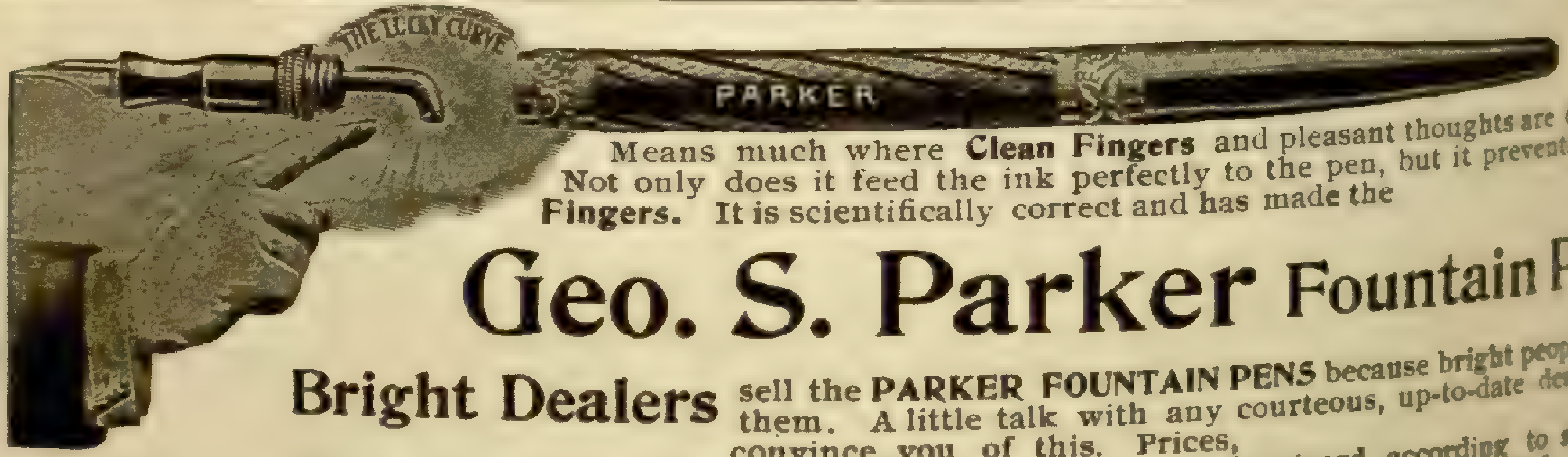

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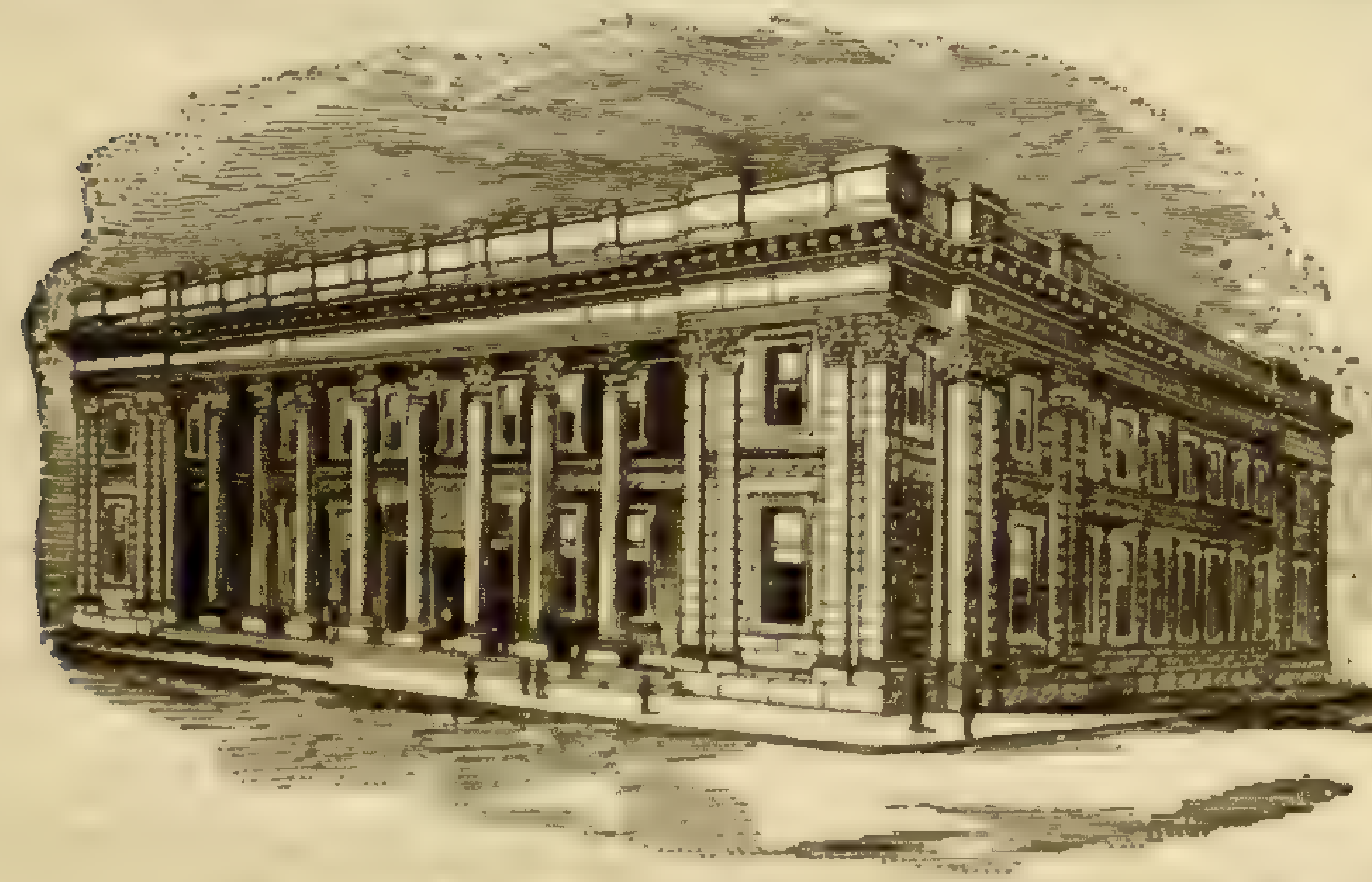

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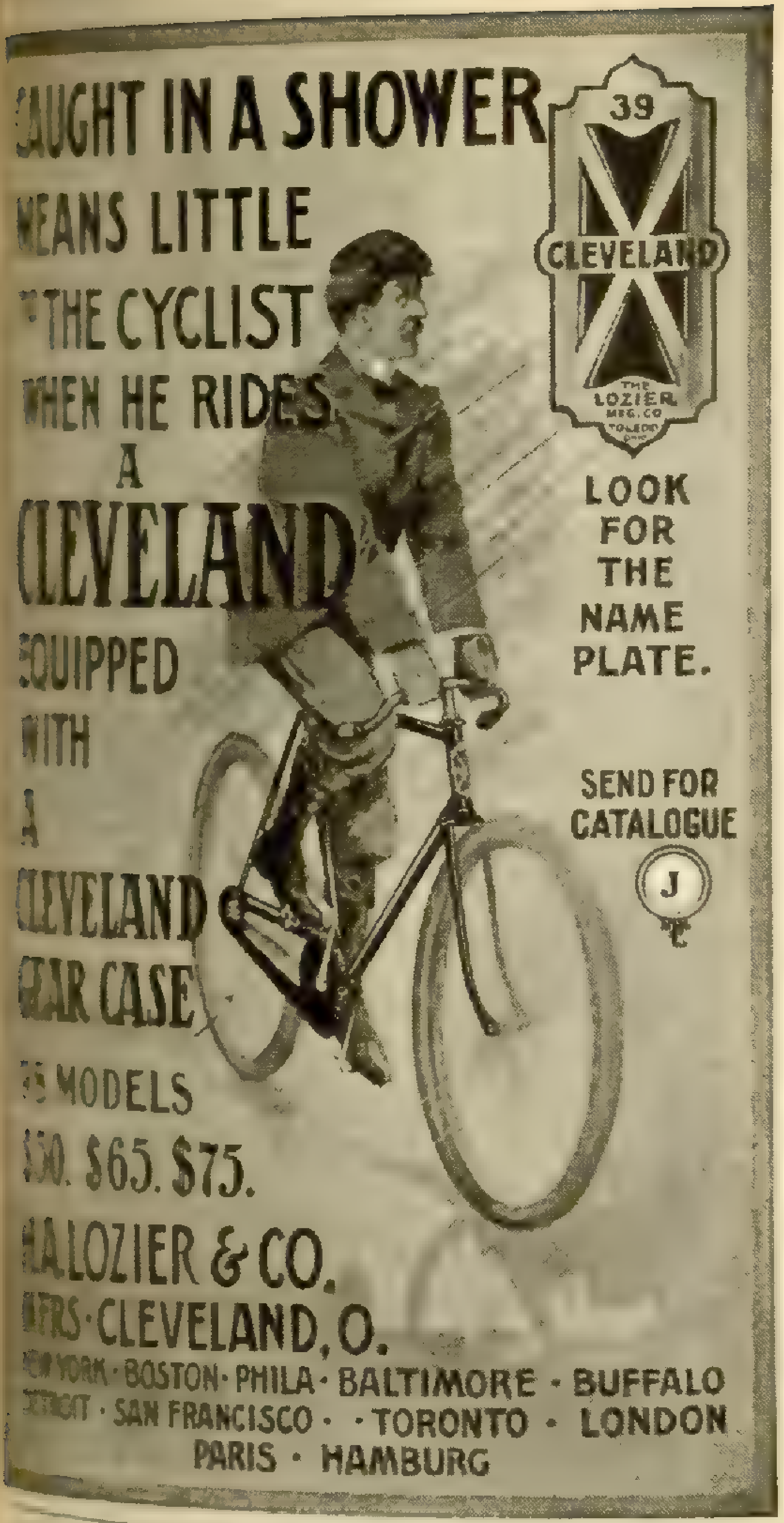
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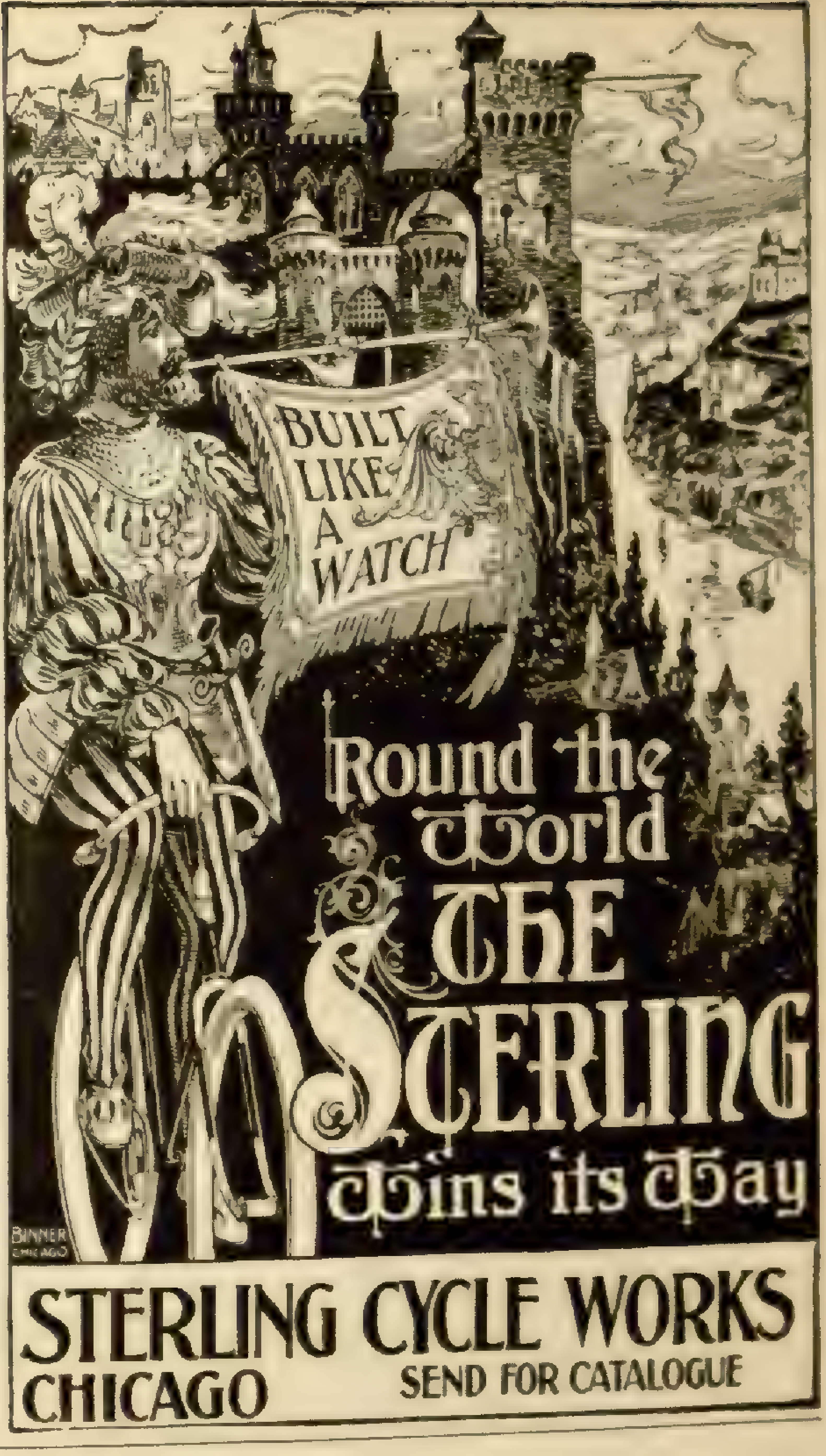
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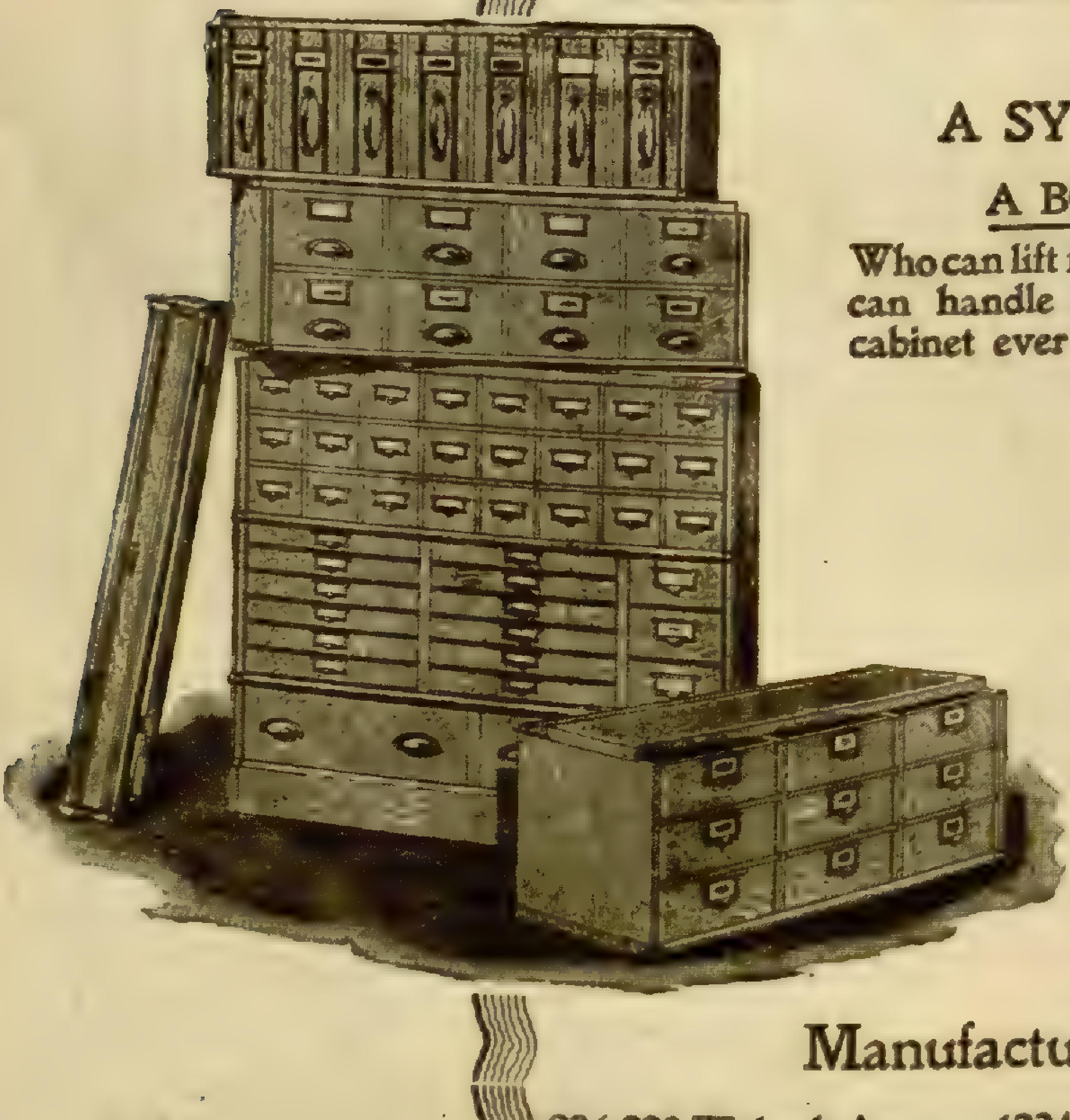

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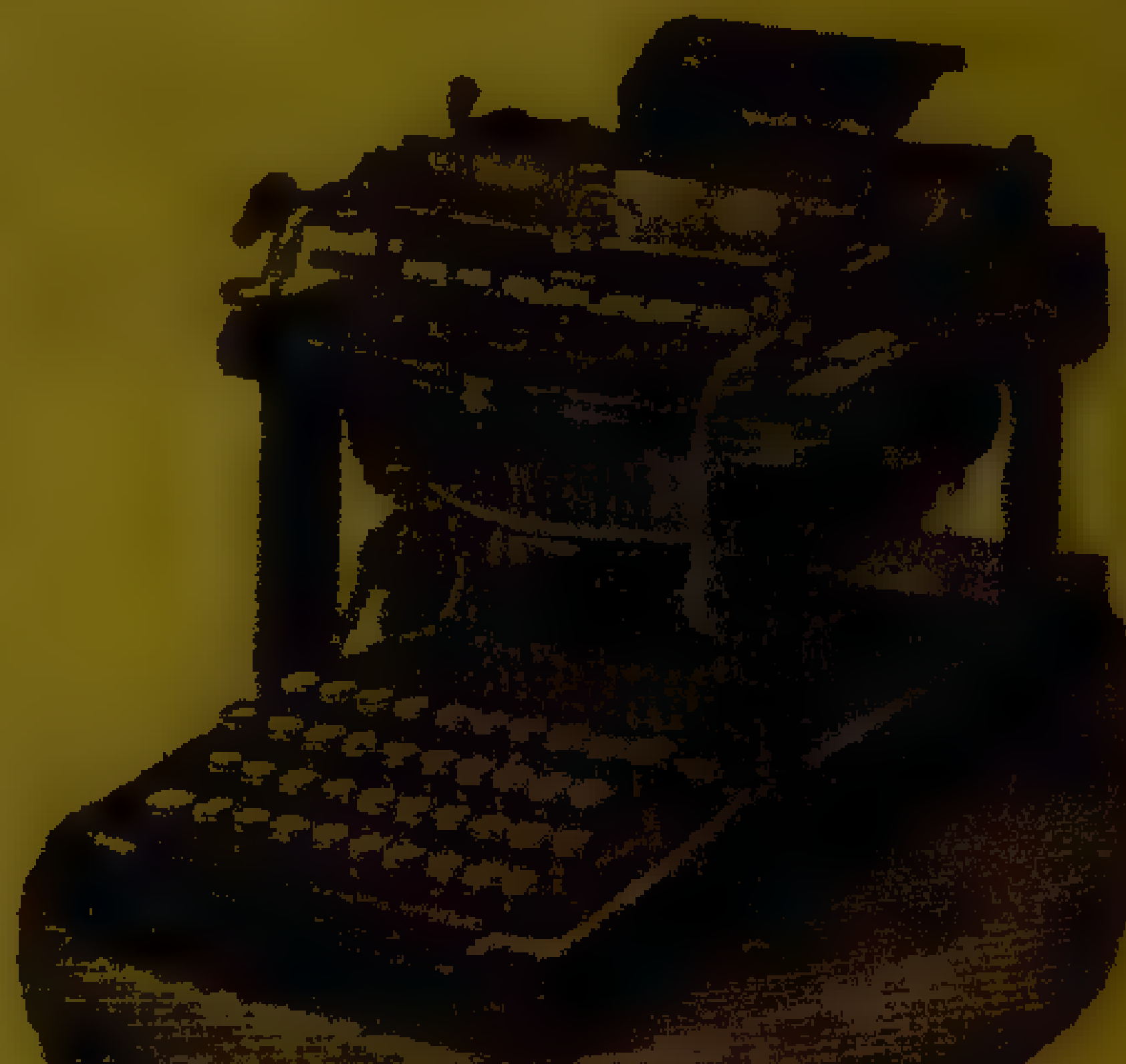

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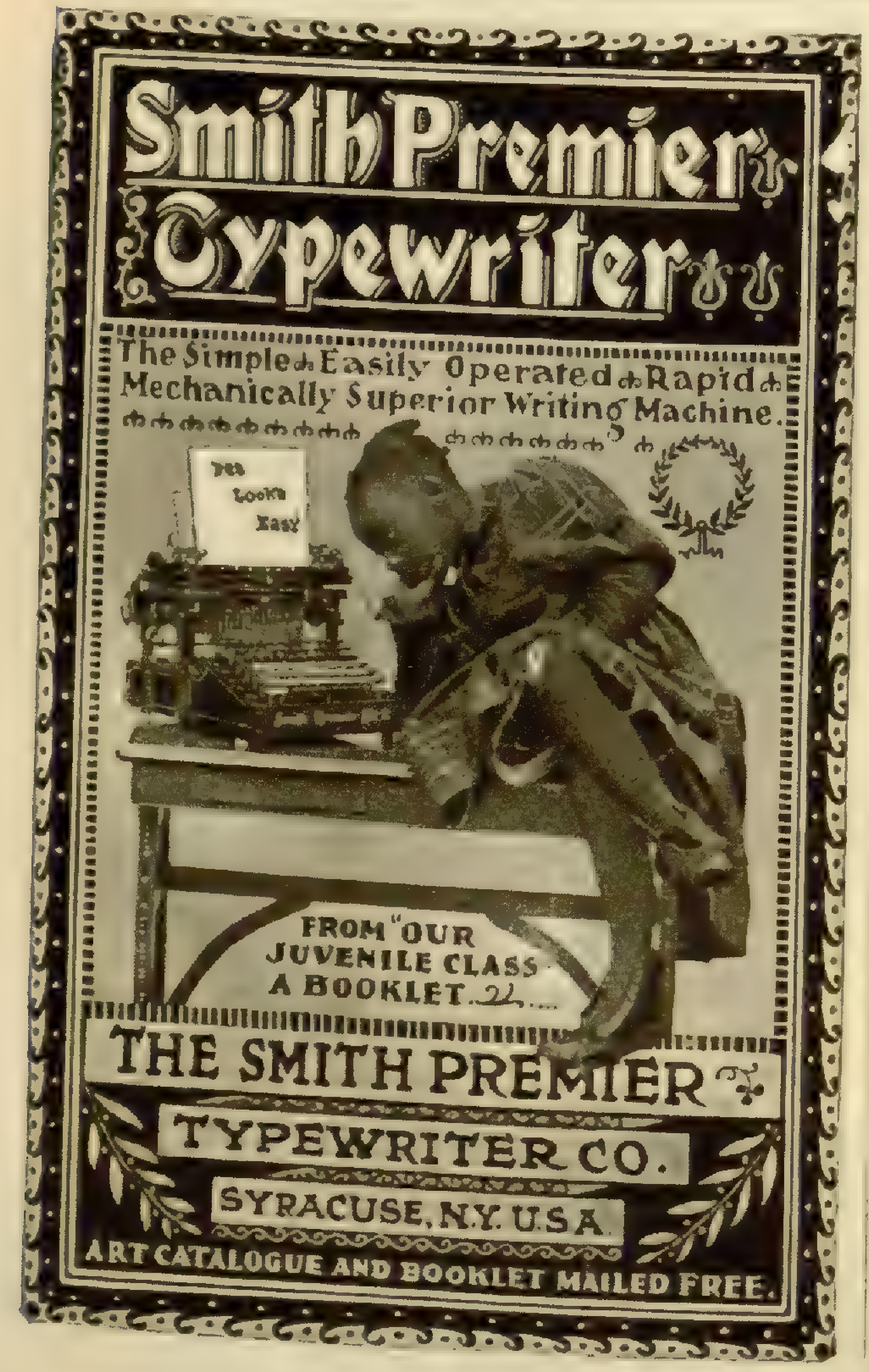

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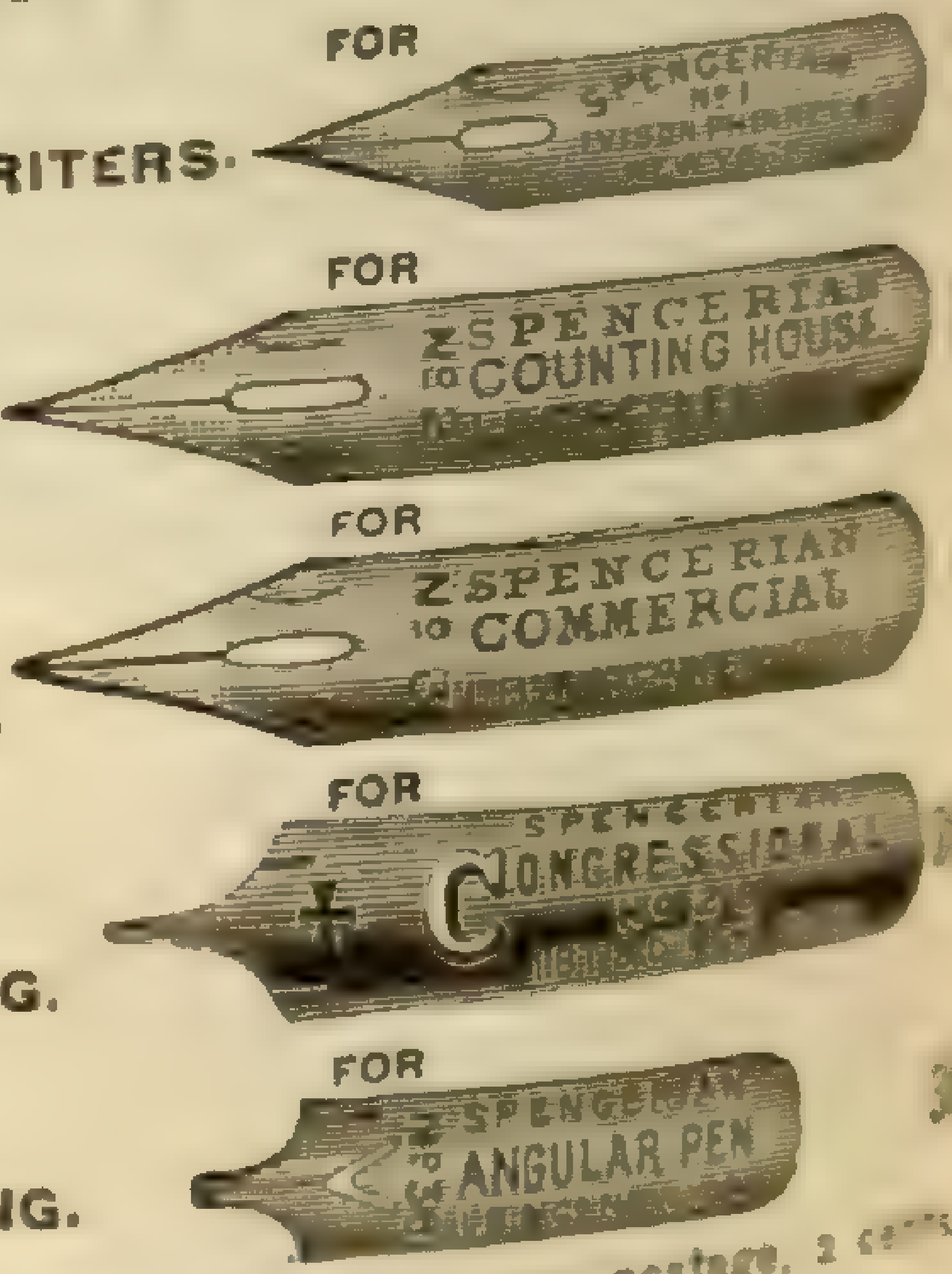

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VOLUME XXV NUMBER 5

BOTANICAL GAZETTE

MAY 1898

THE ORIENTATION OF THE PLANT EGG AND ITS ECOLOGICAL SIGNIFICANCE.

CONWAY MACMILLAN.

As a convenient series of forms in which the embryogeny has been carefully investigated one may select the Archegoniatæ. A number of groups in which genuine eggs are developed thus fall outside the limits of discussion. Among these are the Chlorophyceæ with such genera as Sphæroplea and Coleochæte; the Phæophyceæ, particularly Fucus and its allies; and the Phycomycetes, as for example Peronospora and Achlya. The metaspermic types of segmentation will be found to be derived from certain archegoniate types and will receive incidental attention, but it will be quite unnecessary to enter into an examination of the modified and often degenerate processes that succeed the physiological equivalent of fecundation in Rhodophyceæ. With such limitations there will be presented a review, in succinct form, of certain important types of egg segmentation known to occur among the plants classified by Engler as *Embryophyta zoidiogama*.

BRYOPHYTIC ORIENTATION AND SEGMENTATION TYPES.

Among bryophytes the egg manifests in the Hepaticæ all the types of segmentation that are retained in the higher order. Therefore it will be unnecessary to give any special account for the Musci. Essentially all Musci present segmentations that are ecologically equivalent, with the possible exception of Archidium which seems to be a degenerate type rather than rudimentary. The basal type among Musci seems to be that of Sphagnum, which connects closely with the type of Anthoceros among Hepaticæ. In mosses the most important improvement over Hepaticæ, in the embryogeny, is the early differentiation of at least the distal cell of the embryo as an apical cell, while in some cases the proximal cell also accepts this character and organizes the foot by apical segmentations. In Hepaticæ the distal apical cell is the only apical cell developed, and this does not undergo improvement beyond the hemispherical type, so that apical growth in the hepatic embryo is limited.

Embryogeny of Riccia.—Early researches upon the embryogeny of *Riccia glauca* were conducted by Hofmeister,[1] whose account, however, was quite imperfect. His figure (*l. c. pl. 10, fig. 9*) shows a rather abnormally inclined basal wall. Our exact knowledge of the early stages in this embryogeny are due to Kienitz-Gerloff,[2] who corrected the errors in the original account of Hofmeister and figured the early stages (*l. c. pl. 3*) from the primitive segmentation to the specialization of amphithecium and endothecium. Leitgeb[3] considered the embryogeny of this plant and shows (*l. c. pl. 2, fig. 8*) an early stage in the embryogeny with the normal slightly inclined basal wall. The accompanying figure (*fig. 1*) represents diagrammatically the early stages of the Riccia embryogeny as determined by Hofmeister and Kienitz-Gerloff. The first wall is approximately transverse to the axis of the archegone. Succeeding walls divide the embryo into nearly equal

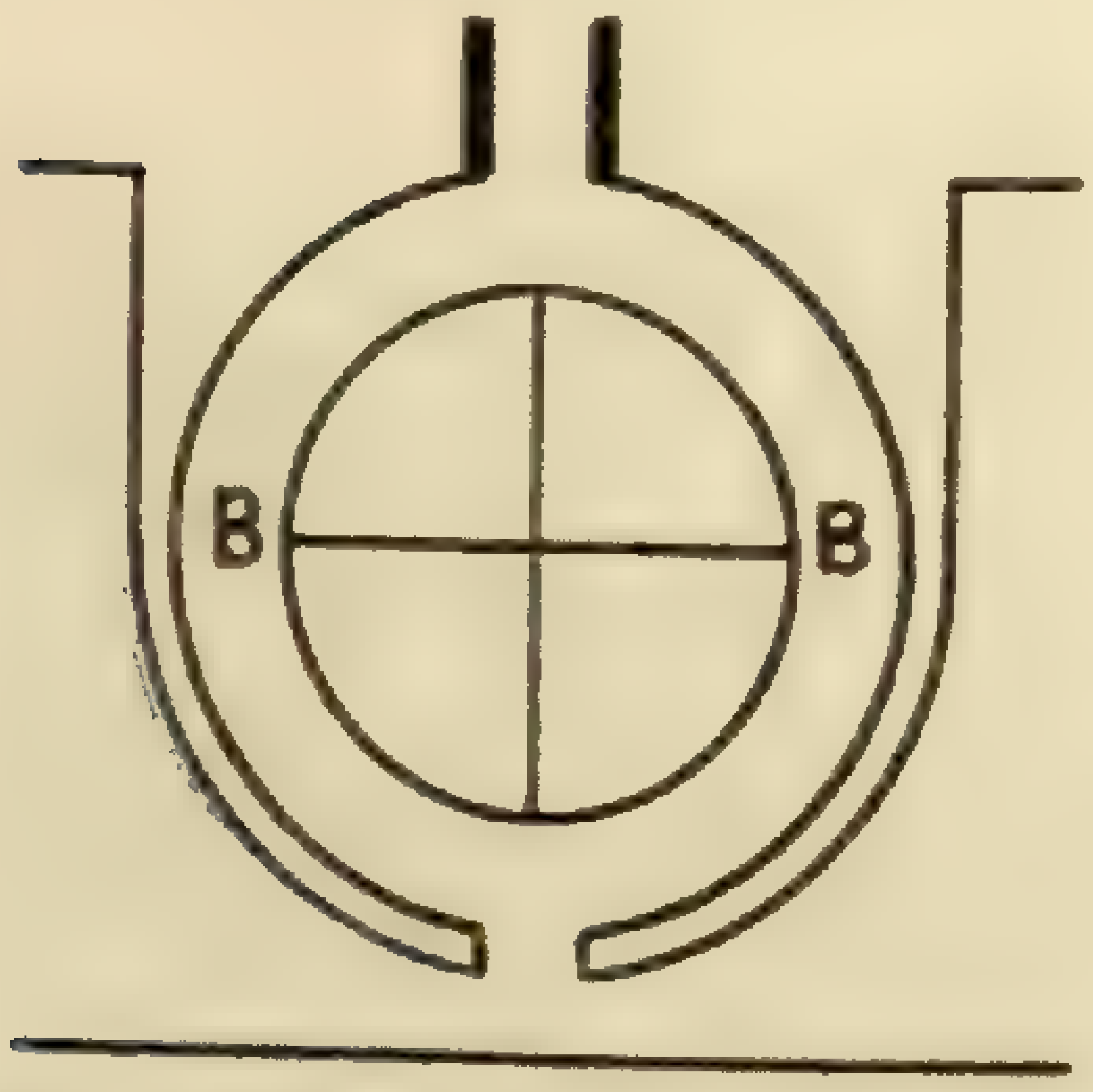

FIG. 1.—Embryo of Riccia.

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[1] Vergleich. Unters. 47. 1851.

[2] Vergleich. Unters. über die Entwickelungsgesch. des Lebermoos-Sporogonium. Bot. Zeit. **32**: 166. 1874.

[3] Unters. über Lebermoos. **4**: 22. 1879.

ctants. Alone among Bryophyta the embryo of Riccia (including here also the closely allied genera Ricciocarpus and Ricciella) shows very slight distal-proximal specialization, if any. The archegone stands perpendicularly upon the thallus, invaginated for protection, and the originally distal hemisphere develops in essentially the same manner as the proximal. The mature sporophyte, a globular body less than a millimeter in diameter, consists merely of a one-layered wall of sterile cells surrounding a homogeneous mass of spores, elaters being absent. The spores are released by disruption of the wall and disorganization of the surrounding tissues of the invaginated thallus and the calyptra.

Embryogeny of Sphærocarpus.— This interesting little plant was not carefully investigated until 1867, when Petounnikow made out some of the principal points in the embryogeny[4] after the early stages which apparently he did not see. In 1875 Kienitz-Gerloff[5] took in hand the investigation of this plant and practically completed it. He showed that while a considerable irregularity existed in young stages, the first wall was approximately transverse. This was succeeded by one or two other transverse walls principally in the hypobasal hemisphere, and finally periclines and anticlines in the epibasal hemisphere served to delimit the amphithecium and endothecium of the capsule. Leitgeb[6] gives a series of figures of the young embryo which together with the excellent series of Kienitz-Gerloff in the paper cited may be regarded as complete. Leitgeb suggests that its embryogeny "strongly resembles that of Fossombronia," but its resemblance seems strongest with the Marchantiaceæ, and probably the place of the plant is not with the Jungermanniaceæ as some taxonomists have thought, but with the simpler relatives of Marchantia. The mature sporophyte is a spherical capsule provided

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[4] Sur les organes reproducteurs du *Sphærocarpus terrestris* Mich. Bull. Soc. Bot. de France 14:137. 1867.

[5] Neue Beitr. zur Entwickelungsgesch. des Lebermoos-Sporogoniums. Bot. Zeit. 33:795. 1875.

[6] Op. cit. 4:69. *pl.* 9. 1879.

with a short foot with bulbous base. Elaters are not present but nutritive cells are found among the functional spore mother cells. In *fig. 2* a diagram of the egg orientation and first segmentation is shown. The black epibasal segment is the ultimately sporogenous area, while the white hypobasal segment does not produce spore mother cells but is sterilized. The distal-proximal specialization which arises in the sporophyte is thus seen to be connected with the first segmentation plane of the egg. As will be noted in the next plant but one examined, such distal-proximal specialization need not necessarily be foreshadowed by the first segmentation plane.

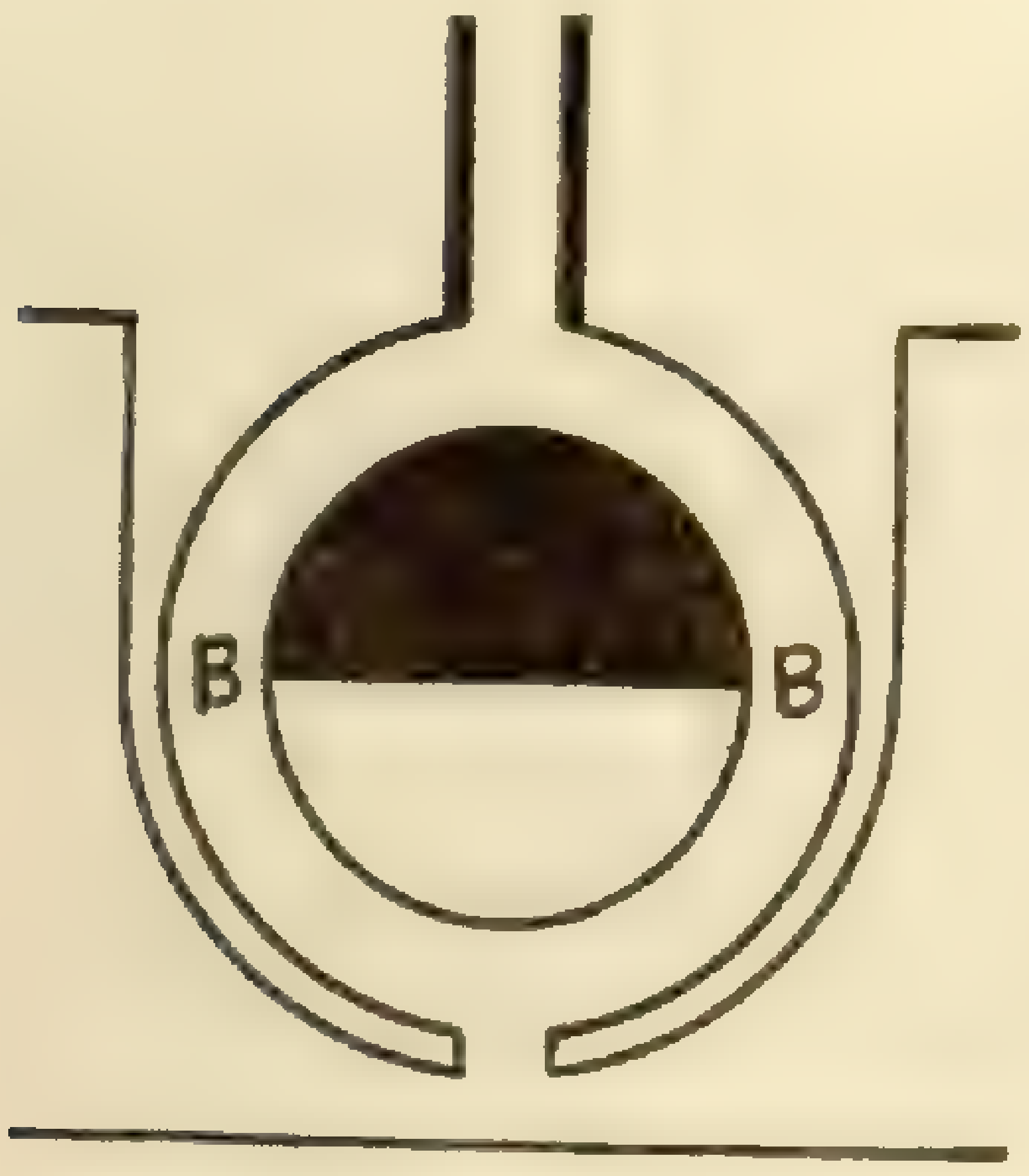

FIG. 2.—Embryo of Sphærocarpus.

Embryogeny of Marchantia.—This genus was studied by Hofmeister,[7] who investigated the embryo of *Marchantia polymorpha.* In the work cited his *pl. 11*, *fig. 16* shows an octant stage; *fig. 30*, of the related plant *Conocephalus conicus*, shows less correctly an early stage in the embryogeny provided with an apical cell which does not then exist. As in the case of the plants previously mentioned, the important researches on the embryo of Marchantia were made by Kienitz-Gerloff[8] whose *pl. 3* in the memoir cited gives eleven figures of young embryos from the quadrant stage up to the differentiation of foot and capsule and the development of wall and archesporium. In all essential particulars this embryogeny resembles that of Sphærocarpus except that secondary transverse walls parallel to the basal wall are not formed in advance of anticlines and periclines in the capsular region. The mature sporophyte is an ovoid or spherical capsule upon a short cylindrical foot which elongates during the last stages of maturation and projects the capsule beyond

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[7] Op. cit. 56. 1851.

[8] Vergleich. Unters. u. s. w. Bot. Zeit. 32: 167. 1874.

the calyptra. In one particular, however, there is pretty generally in the Marchantiaceæ of higher rank than Sphærocarpus a modification of the primitive position of the sporophyte with reference to the horizon. Instead of being erect it is inverted more or less completely. This is due to the inversion of the archegone which, although developed dorsally on the thallus, is carried into a ventral position by displacements of growth, so that the neck of the archegone points towards the substratum. As the archegone is carried to an inverted position the egg must also be unless it rotates in the venter, a process which does not take place in ontogeny although apparently it does in phylogeny. *Fig. 3* shows in diagrammatic fashion the first segmentation stage of the Marchantia egg with the epibasal hemisphere shown black as before and now directed downward instead of upward. In either case, however, whether the embryo of Sphærocarpus or Marchantia be considered, it must be noted that the epibasal hemisphere is essentially the distal segment of the egg, while the hypobasal is as essentially the proximal. In Bryophyta a strong distinction arises between these differently situated segments and in pteridophytic types of embryogeny where the egg is frequently rotated to one side or even inverted in the archegone under ecological stress, it is always possible to distinguish the segment which is the homologue of the originally distal segment and this, whatever its position in the archegone, or with the thallus or the horizon, is termed the epibasal segment. The conception of an epibasal and hypobasal segment is therefore seen to be one of phylogeny rather than of embryogeny.

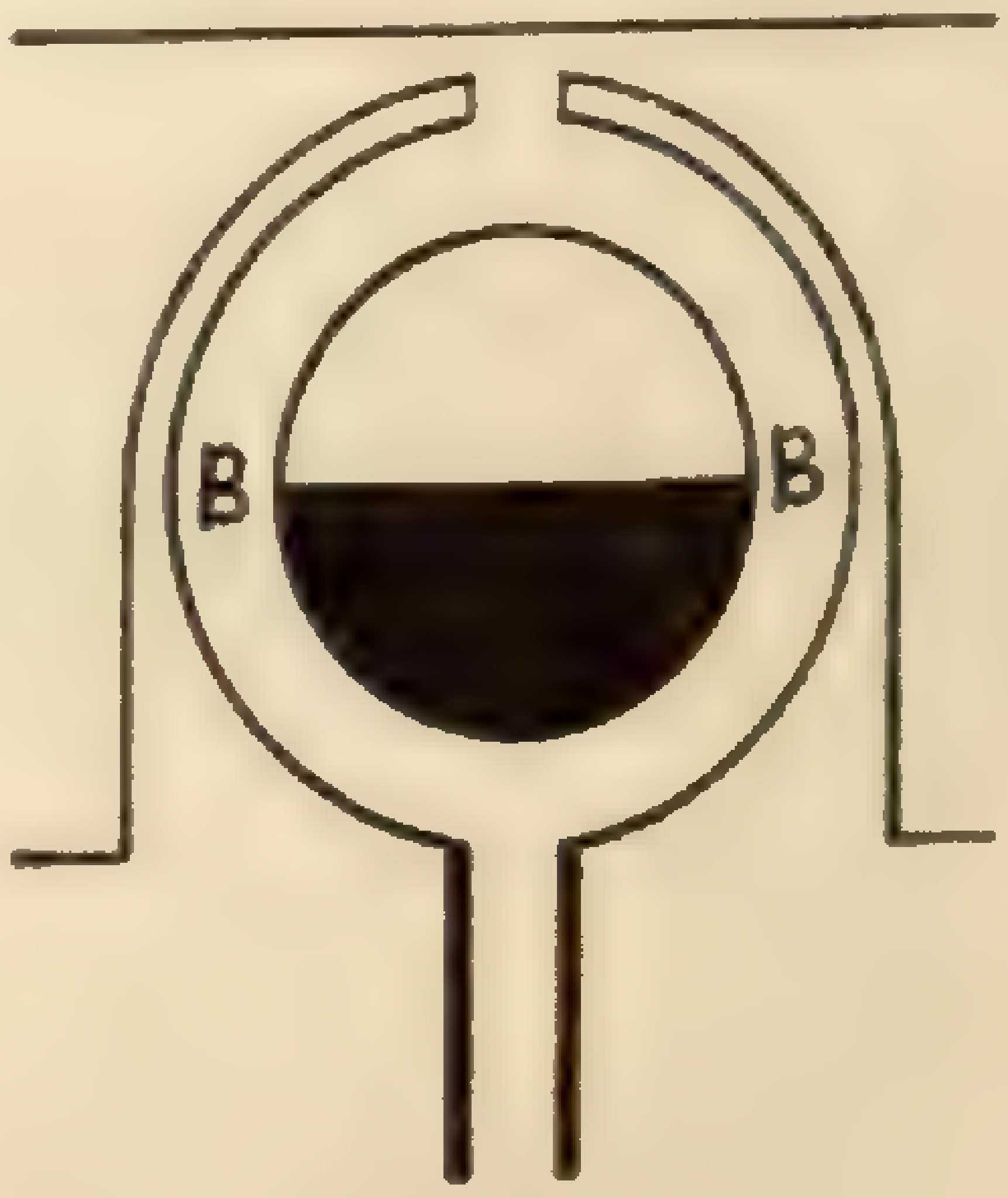

FIG. 3.—Embryo of Marchantia.

Embryogeny of Anthoceros.—While important work on the sporophyte of Anthoceros was accomplished by Schacht[9] in

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[9] Beitr. zur Entwickelungsgesch. der Frucht und Spore von *Anthoceros laevis*. Zeit. 8:457. 1850.

1849, it was not until Hofmeister showed the independence of the rudimentary spore-producing organism from the thallus that a clear idea was possible of the early stages. Schacht's *pl. 6, fig. 2*, of the work cited, shows a young sporophyte of about twenty cells, but drawn as if a branch of the thallus. The position of the walls, however, is correctly indicated. Hofmeister,[10] in 1851, cleared up the embryogeny of this plant so far as concerned the first segmentations. His *pl. 1, fig. 36* of the work cited is practically correct, although not so much can be said for *fig. 39*. It is to Leitgeb and Waldner that we owe the modern knowledge of the Anthoceros embryogeny. Leitgeb[11] first discussed it fully in a special paper, and later Leitgeb and Waldner,[12] in their joint part of Leitgeb's classic work on the Hepaticæ, described and figured with accuracy the young plants from the first segmentation on to maturity. In Leitgeb and Waldner's memoir, *pl. 1, fig. 1* shows most clearly a young eight-celled stage, while earlier phases are described in the text. The originally formed wall is in this plant not the basal wall, but the median or transverse wall, running parallel with the axis of the archegone and dividing the egg into two halves, either anterior-posterior or right and left, since the archegone occupies a perpendicular position imbedded in the upper layers of the thallus. *Fig. 4* shows the ovoid shape of the egg, the vertical plane of the first segmentation, and the later formed plane of the basal wall which divides the egg into capsular area and foot area quite as in the Marchantiaceæ. In this egg the distal-proximal specialization is strongly marked. Not only does this appear in the position of the basal wall below the middle of the egg, but in the ovoid shape of the egg itself. The slender, columnar form

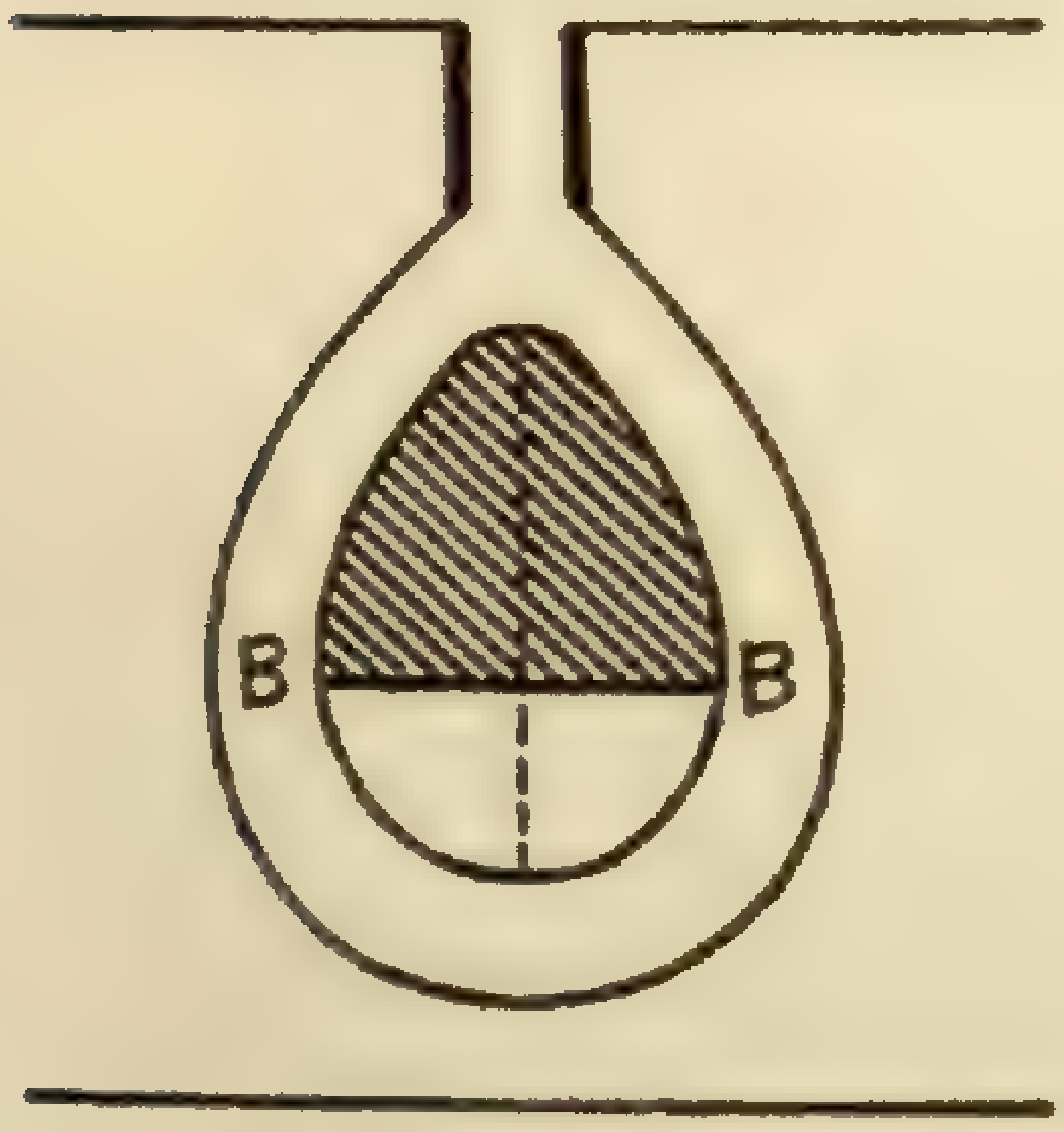

FIG. 4.—Embryo of Anthoceros.

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[10] Op. cit. 5. 1851.

[11] Entwickelung der Kapsel von Anthoceros. Sitz. der K. Acad. Wiss. 73.

[12] Unters. über der Lebermoose 5: 21.

of the Anthoceros capsule capable of evolutional modification into the capsule of Sphagnum on the one hand, or the strobilus of Phylloglossum on the other, is prefigured to a degree in the egg. That the basal wall should not be the first wall formed is apparently a peculiarity not confined to this genus of plants, for in fern embryogeny the same irregularity has been noted. From the further development of the segments it is quite clear that the vertical wall first formed is by no means basal, as it is in Pilularia, and the only explanation at all satisfactory is the one given here, that it is in reality median or transverse.

Embryogeny of the Jungermanniaceæ.—In this important family of Hepaticæ there is no new type developed. Strong distal-proximal specialization is universal, and the base of the capsular tract is converted into a sterilized stalk, so that the elevation of the sporogenous area is brought about by an organ derived from the epibasal hemisphere, rather than from the hypobasal, as in Sphærocarpus. In Marchantiaceæ, as is well known, the elevation of the sporogenous area is a function not of any sporophytic organ, but principally of the archegoniophore stalk which elongates, carrying up into the air the circle of attached sporogonia. In Fossombronia, Pellia, Frullania, Lejeunia, and the other Jungermanniaceæ the embryogeny is of essentially the type described for Sphærocarpus. An additional elongation of the sporophyte is provided for in the manner described, but in general the diagram of the Sphærocarpus embryo would suffice for that of any of the others, as for any moss.

Comparison of bryophytic types of orientation and segmentation.—A glance at the figures will show that there is really but one type of egg orientation represented in this group. In Riccia there is no sharp differentiation between the epibasal and hypobasal hemispheres so far as concerns their further development. In the higher genera the hypobasal segment is invariably sterilized, while the epibasal hemisphere is wholly or in part developed into a capsular body, maturing spores with or without accessory cells in the form of nutritive cells, elaters, or columella cells. In all cases the hypobasal hemisphere is proximal, while the epibasal is distal. The archegone may be erect, horizontal or inverted, but the orientation is always normal and primitive; that is to say, the epibasal hemisphere, originating as the distal half of the egg, retains constantly the distal position. This distal-proximal arrangement of the first egg segments is not disturbed in any important sense by the retardation of the basal plane in such an embryo as that of Anthoceros. Without further discussion at this point, it may be well to pass at once to the consideration of pteridophytic embryogenies, in order that their new developments may be brought before the attention.

PTERIDOPHYTIC ORIENTATION AND SEGMENTATION TYPES

Among certain genera of pteridophytes it is probable that the primitive bryophytic orientation of the egg is retained. Among others it is profoundly altered, so that the inverted embryogeny of the Lycopodinæ and of the leptosporangiate ferns presents itself for consideration. It will be shown later that the inverted embryo of the club-mosses and the semi-inverted embryos of Polypodium and Alsophila are not directly comparable, the inversion having originated under probably different stimuli in the ancestral types; that is, in a word, there is not one type of inverted orientation to be set over against the one primitive type of normal orientation. On the contrary, inversion, semi-inversion, or rotation of the egg may be shown to have arisen in different phyla under different conditions.

Embryogeny of Equisetum.—This plant was among those studied by Hofmeister,[13] who gives some correct figures of early stages in *pl. 17* of the work cited. His *fig. 16* is particularly excellent. The very early two-celled stage of the embryo is not shown, but the horizontal first division plane is duly announced.

[13] Ueber die Keimung der Equisetaceen. Abh. K. S. Gesellsch. d. Wiss. 4:172.

Sadebeck[14] gave a full account of the Equisetum embryogeny in 1878, and his figures serve to illuminate all the important stages. The basal wall divides the egg into a distal half as distinguished from a proximal. The distal or epibasal hemisphere develops into the shoot tract, while the proximal retains its ancestral character of a foot from which, however, the root springs endogenously (*fig. 5*). It may be regarded, I think, that the type of embryogeny shown by Equisetum is the most primitive among pteridophytes, and indicates the probable phylogenetic significance of the root as an embryonic organ of Pteridophyta. The root is developed as an emergence from the conduction-path of the nursing foot. Throughout the vegetable kingdom it almost universally arises from internal tissues, and may be regarded as a branch of the stele. The precise behavior of the hypobasal hemisphere of Equisetum, which enlarges by cell-division and growth into a bulbous body and then develops a root from an apical cell, not superficial, may be taken for a recapitulation of the original evolution of the root as an organ of the sporophyte. In this sense root is not homologous with stem, and is, indeed, a new structure. It seems to be, for the archegoniate series of plants, essentially first of all an absorptive tract, and it comes into existence through adaptation to its surroundings of the sporophyte endowed with a progressively larger photosynthetic area. This conception is in direct contradistinction to an older view, that root as a morphological area is merely the proximal end of the axis, and that its primitive function was support rather than absorption.

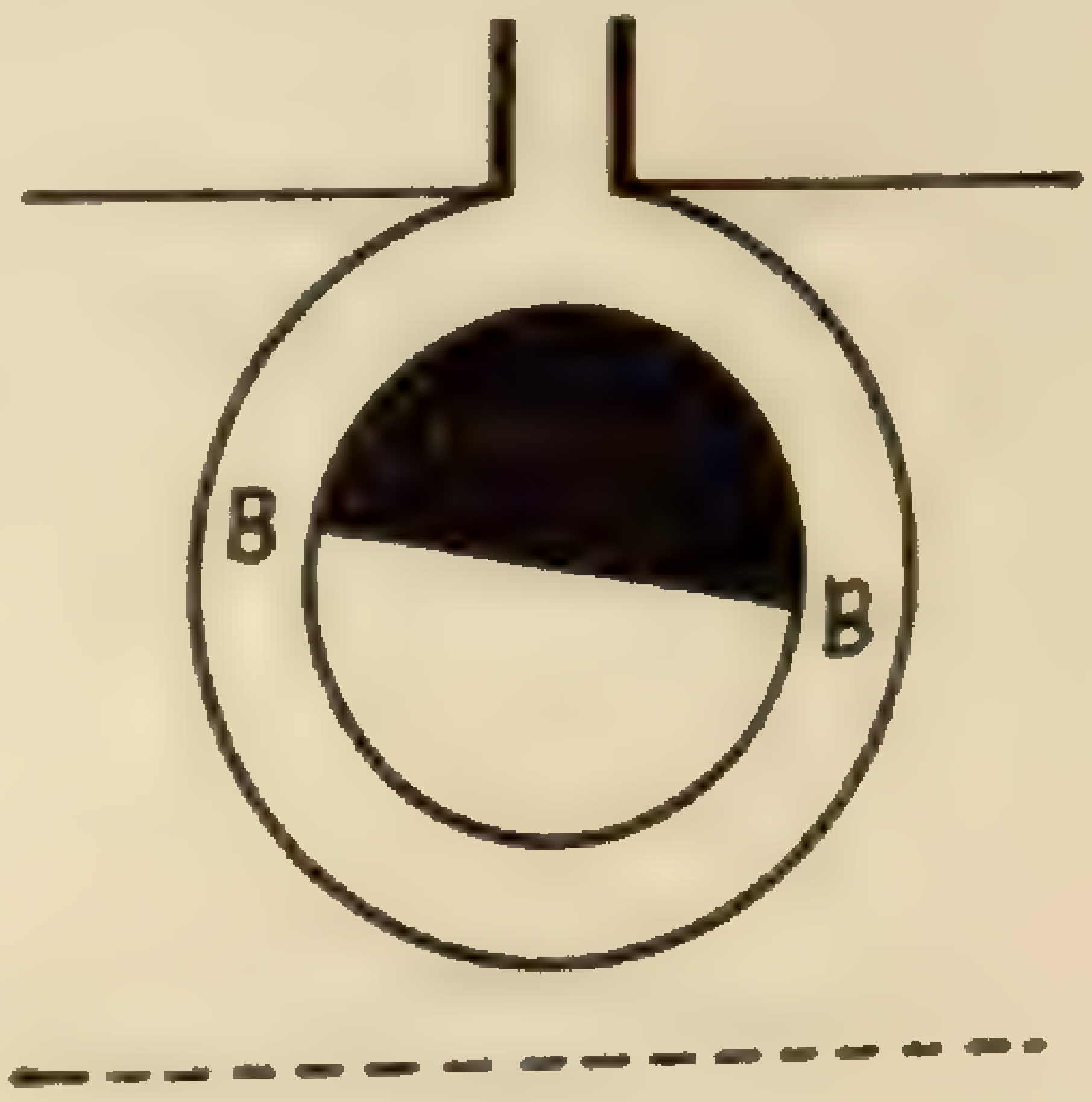

FIG. 5.—Embryo of Equisetum.

Embryogeny of Angiopteris.—Our knowledge of the early stages in the development of the Angiopteris sporophyte is due

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[14] Die Entwickelung des Keimes der Schachtelhalme. Jahrb. Wiss. Bot. 11: 575. 1878.

to Farmer[15] who has carefully investigated the first segmentations. The archegones are situated upon the lower side of the rather thick and massive prothallium. The eggs segment by a transverse basal wall followed by a median. Unlike the egg of Marchantia this egg of Angiopteris retains its original orientation with reference to the horizon, although the archegone is displaced, for protection, to the lower surface of the prothallium. The epibasal hemisphere is directed upward, hence away from the neck of the archegone, and the egg must be conceived to have rotated in the reverse direction to the archegone as it passed from the original dorsal position, as in Anthoceros, to the ventral position generally characteristic of the ferns. *Fig. 6* shows the position of the egg and its segments in the inverted archegone, and should be compared with *fig. 3*, that of Marchantia, where the inversion takes place during ontogeny and the egg is not rotated. In Angiopteris and the other Marattiaceæ which have been studied, this inversion does not take place as in Marchantia, during the life of an individual prothallium, but has evidently resulted from a slow adaptation. Opportunity has thus been given for the egg to change its position from time to time as the slight inclination of the archegone made necessary, if it was to retain its normal position with reference to the surface of the substratum. Consequently the Angiopteris stem and cotyledon bore through the prothallium, and thus come to independent illumination and the plant develops its sporangia a sufficient distance above the substratum to insure spore distribution.

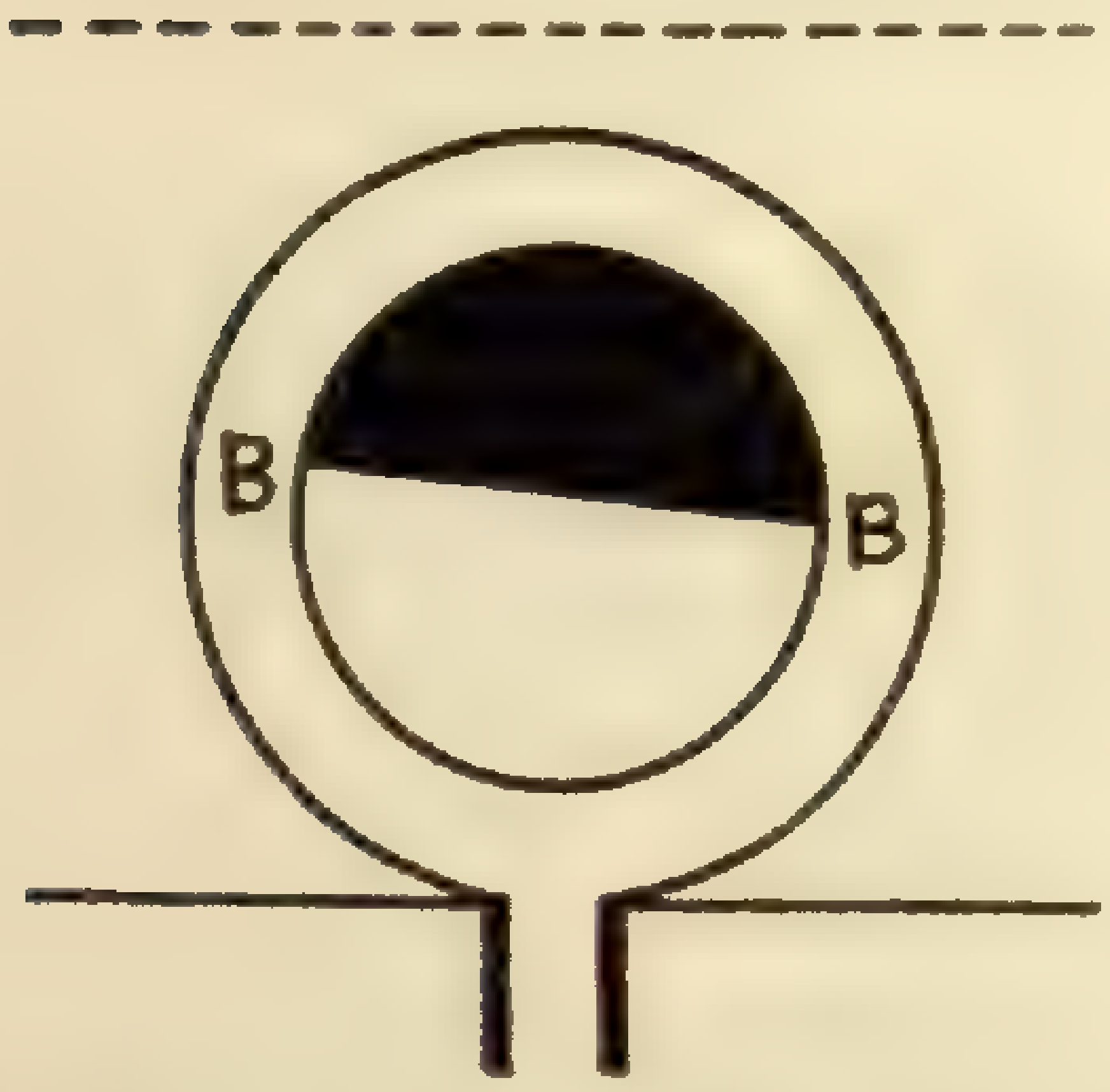

FIG. 6.—Embryo of Angiopteris.

Embryogeny of Isoetes.—The embryogeny of this plant has been studied by a number of observers of different degrees of ability, but, it seems to the writer, has never received the proper

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[15] On the embryogeny of *Angiopteris evecta*. Ann. of Bot. 6: 265. 1892.

terpretation. Hofmeister's[16] classic memoir is the first paper
importance that deals with the embryogeny. In *pl. 2, fig. 20*
the work cited he figures the first segmentation stage, and in
21 shows an octant stage. Other less correct intermediate
ages are figured in *pl. 3*, but the *fig. 13*, which gives a view of
n embryo with developed cotyledon, is excellent. Nearly
rty years later Kienitz-Gerloff[17] undertook an examination of
is plant, and concluded a research characterized by accurate
servation of the earlier stages, coupled with erroneous con-
ption of the later. His series of figures in the work cited
arry the embryo from the stage just succeeding the octant
age up to ligular development. Farmer[18] in 1890 incidentally
nsidered the embryogeny and came to the conclusion that the
first root was adventitious.

The segmentation of the Isoetes egg is briefly as follows:
he egg is cleft by a wall nearly perpendicular to the axis of
rchegone. From the hemisphere next the archegone neck,
ter quadrant and octant walls have appeared, are developed
e cotyledon, the root, and, later, probably from the cotyledon
adrant (not the root quadrant as has been suggested), the
em. The hemisphere away from the neck develops only a
ass of cells, which has been generally considered as the foot,
d so described. Now the development of a primary root
m the epibasal hemisphere is so difficult an hypothesis to
cept that Farmer's solution of the dilemma by considering
e first root an adventitious organ would necessarily be adopted
another explanation were not at hand. It can properly be
estioned, however, whether the first transverse wall formed is
ally the basal wall. This has been the current hypothesis,
d Isoetes in its embryogeny has been compared with Equi-
etum, a plant which manifests, as has been indicated above,
e normal bryophyte type of orientation of its egg. If, how-

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[16] Zur Entwickelungsgeschichte der *Isoetes lacustris.* Abh. K. S. Gesellsch.
4: 131.

[17] Ueber Wachsthum und Zelltheilung und die Entwickelung des Embryos von
Isoetes lacustris. Bot. Zeit. **39**: 761. 1881.

[18] On *Isoetes lacustris.* Ann. of Bot. **5**: 37. 1890.

ever, it be supposed that, as is certainly the case in Anthoceros, the first wall formed in the Isoetes embryo is not the basal wall, but the transverse, there is much less difficulty. It is then possible to see how the root and foot may develop from the hypobasal hemisphere, not shaded in *fig.* 7, while from the epibasal develops the strong cotyledon and a group of irregular cells which are generally regarded as constituting a portion of the foot, but should more probably be considered to be a poorly developed leaf-structure. Only half of what has been considered foot in the Isoetes embryo is here retained in that morphological category. The remainder is considered to be aborted leaf functioning as foot. The true epibasal area gives rise to the shoot while the true hypobasal area gives rise to the root. Thus the difficulty of supposing root to originate from an epibasal hemisphere is readily avoided, and by analogy with Anthoceros no violence is done to accepted ideas of embryology. In brief an Isoetes egg may be regarded as an Angiopteris egg turned through an angle of 90° in the archegone cavity, and cut by the transverse wall before the epibasal wall appears.

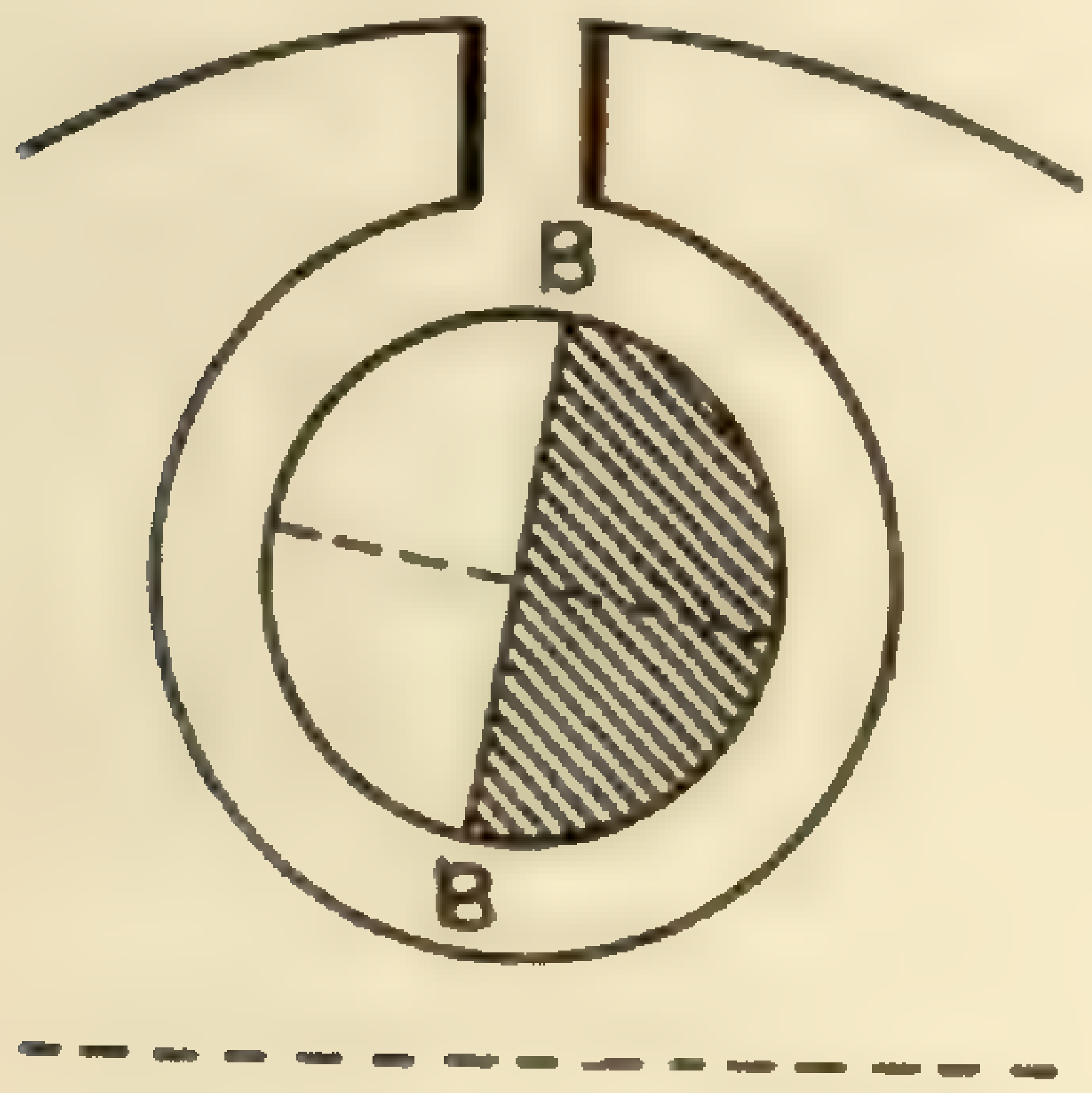

FIG. 7.—Embyro of Isoetes.

Embryogeny of Pteris.—The leptosporangiate fern embryo has been studied by a large number of observers, the first thorough work being that of Hofmeister,[20] who made out correctly the first divisions. As in the case of many of the lower plants the complete study was accomplished later by other observers. Goebel[21] contributed some important observations in a paper primarily devoted to prothallial structure, and Kienitz-Gerloff[22] estigated the embryos of Pteris, Aspidium, Adiantum, and mnogramme, giving in his *pl. 3* the figures of Pteris embryny which have become classic. The first wall in the Pteris bryo runs almost parallel with the archegonial axis, transrse to the prothallium, and divides the egg into a smaller anterior epibasal and a larger posterior hypobasal hemisphere. The normal position of the archegone is ventral, so that at first the root and foot octants are directed obliquely upward. If, however, the archegone is abnormally produced upon the upper side or (sometimes normally) upon the margin of the prothallium the orientation is not essentially modified with reference to the archegone. This is the reverse of the condition observed Marchantia, but, as in the liverwort, there is no revolving the egg in its archegone venter. *Fig. 8* shows the normal tion of the egg, the epibasal hemisphere being directed ward the morphological apex of the prothallium and obliquely toward the substratum.

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[20] Ueber Entwickelungsgeschichte und Bau der Vegetationsorgane der Farnkräuter. Abh. K. S. Gesellsch. Wiss. **5**: 615.

[21] Entwickelungsgeschichte des Prothalliums von *Gymnogramme leptophylla.* Bot. Zeit. **35**: 689. 1877.

[22] Untersuchungen über die Entwickelungsgeschichte der Laubmoos-Kapsel und die Embryo-Entwickelung einigen Polypodiaceen. Bot. Zeit. **36**: 49. 1878.

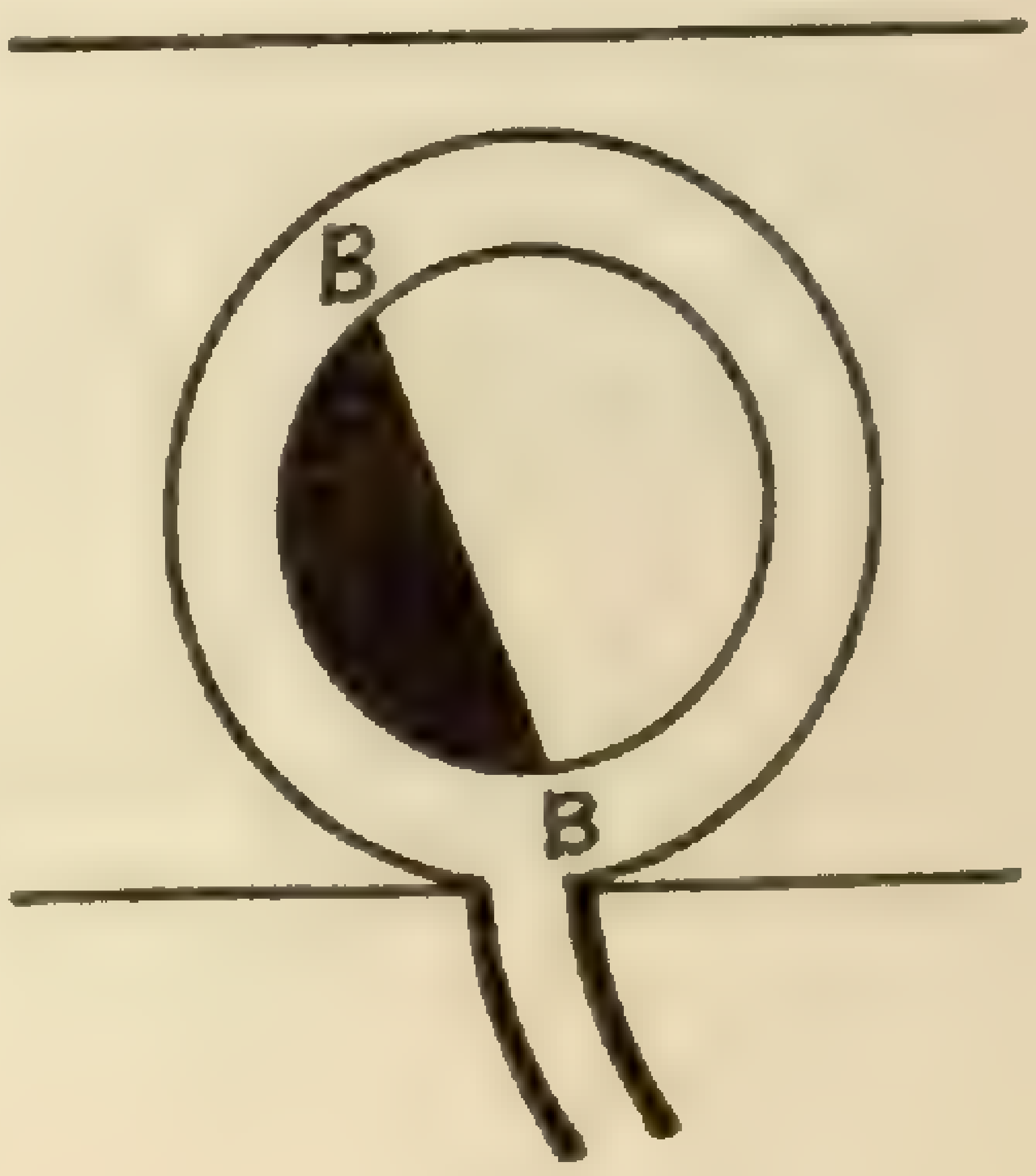

FIG. 8. Embryo of Pteris.

Embryogeny of Marsilia.—The Hydropterideæ have received their share of investigation during the last fifty years. Hofmeister[23] in 1851 examined the embryo of Pilularia, and later Hanstein[24] made a very complete study of the Marsilia embryogeny, offering in *pl. 11* of the work cited numerous satisfactory figures of the early stages. As in other leptosporangiate and, indeed, as in all heterosporous ferns, the basal wall is parallel with the axis of the archegone. Here, however, unlike Isoetes, the

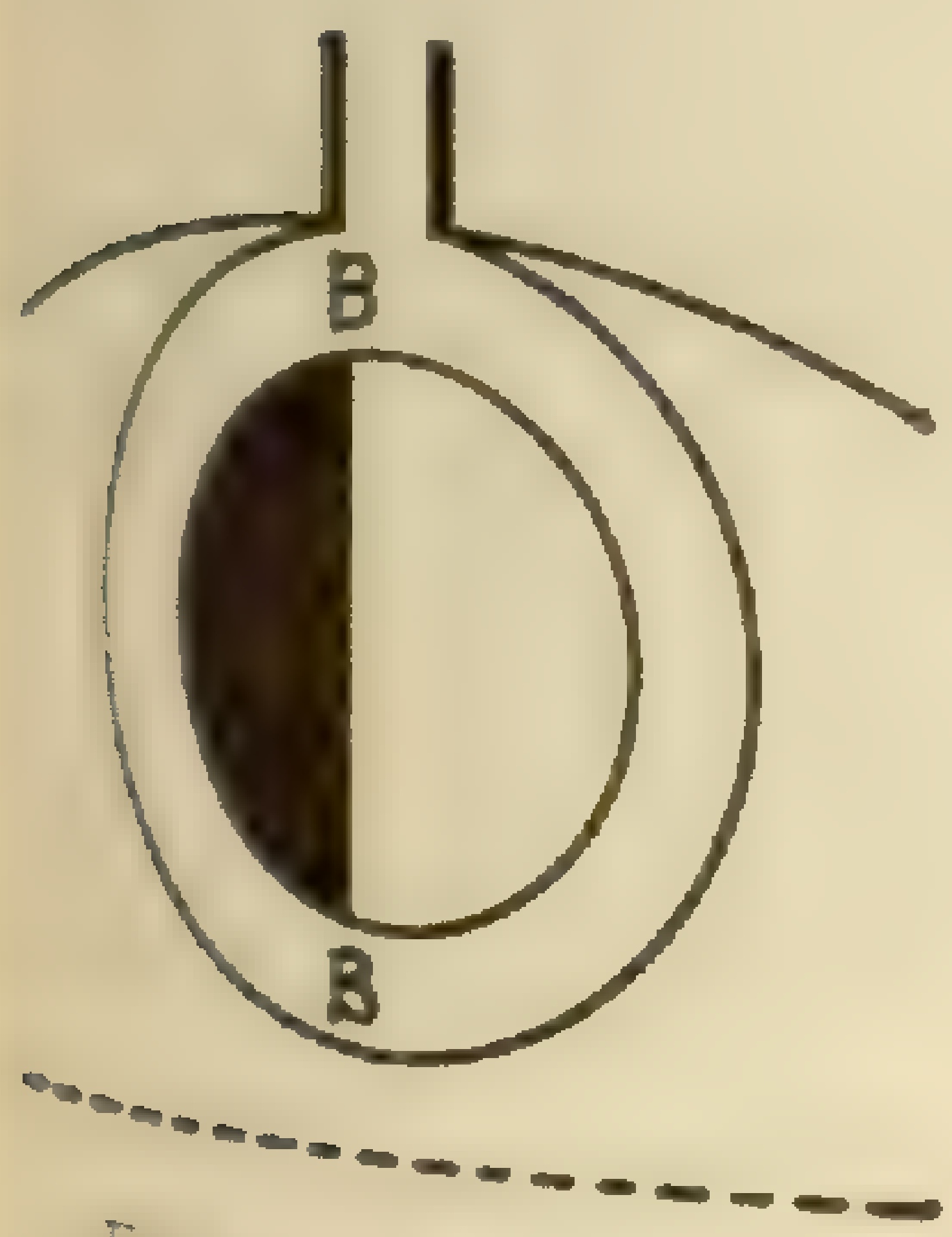

FIG. 9.—Embryo of Marsilia.

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[23] Vergleich. Unters. 106. 1851.

[24] Die Befruchtung und Entwickelung der Gattung Marsilia. Jahrb. wiss. 4: 197. 1866.

first wall to form is the basal wall, separating, as in Pteris, a smaller laterally-placed epibasal hemisphere from a larger hypobasal. In *fig. 9* the orientation is indicated as described, and the further development of the hemispheres, as in the case of Pteris, is too well known to need any extended description.

Embryogeny of Lycopodium.—For many years the sole investigated lycopodineous embryo was that of Selaginella so ably studied by Pfeffer,[25] but in 1884 Treub[26] presented the first figure of an embryonic Lycopodium plant, something which had been diligently looked for during many previous years. In this first paper the account was incomplete, but two years later Treub[27] was able to announce most of the stages in the embryogeny of *Lycopodium phlegmaria.* Confirmation of Treub's researches was given within a year by Goebel,[28] who, however, does not figure any young stages of the embryos studied by him, his sketch of the young plant of *Lycopodium inundatum* being about as far along in development as was Treub's *Lycopodium cernuum* embryo of his 1884 contribution. From the brilliant investigations of Treub and Pfeffer in particular the embryogeny of the Lycopodinæ may now be said to be thoroughly known, although as for so many other groups the foundation here was really laid by Hofmeister,[29] who figured as long ago as 1851 a two-celled embryo of *Selaginella denticulata*, and showed the peculiar suspensor in its proper relation to the rest of the embryo. In Lycopodium, more instructive than Selaginella because its prothallium is less vestigial, the archegones may be regarded as dorsal, and the egg within the archegone segments perpendicularly to the archegone axis, as in Equisetum. It is, however, the hemisphere towards the base of the archegone which has the power of principal development, and it is therefore this hemisphere which must be regarded as epibasal. The hemisphere toward the archegone neck forms the well-known suspensor-cell, and is clearly the homologue of the foot in mosses, liverworts, equisetums, and ferns. The first root in Lycopodium and Selaginella together with a nursing organ, misnamed the "foot," arise adventitiously from the epibasal hemisphere. As compared, then, with Equisetum the egg of Lycopodium must be regarded as having undergone rotation through an angle of 180°, bringing the primitive hemispheres into a position just the reverse of their original one.

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[25] Die Entwickelungs. des Keimes der Gattung Selaginella. Hanst. Bot. Abh. **1**:32. 1871.

[26] Études sur les Lycopodiacees. Ann. Jard. Buitenzorg **4**:129. 1884.

[27] Études sur les Lycopodiacees. Ann. Jard. Buitenzorg **5**:115. 1886.

[28] Ueber Prothallium und Keimpflanzen von *Lycopodium inundatum.* Bot. Zeit. **45**:169. 1887.

[29] Vergleich. Unters.

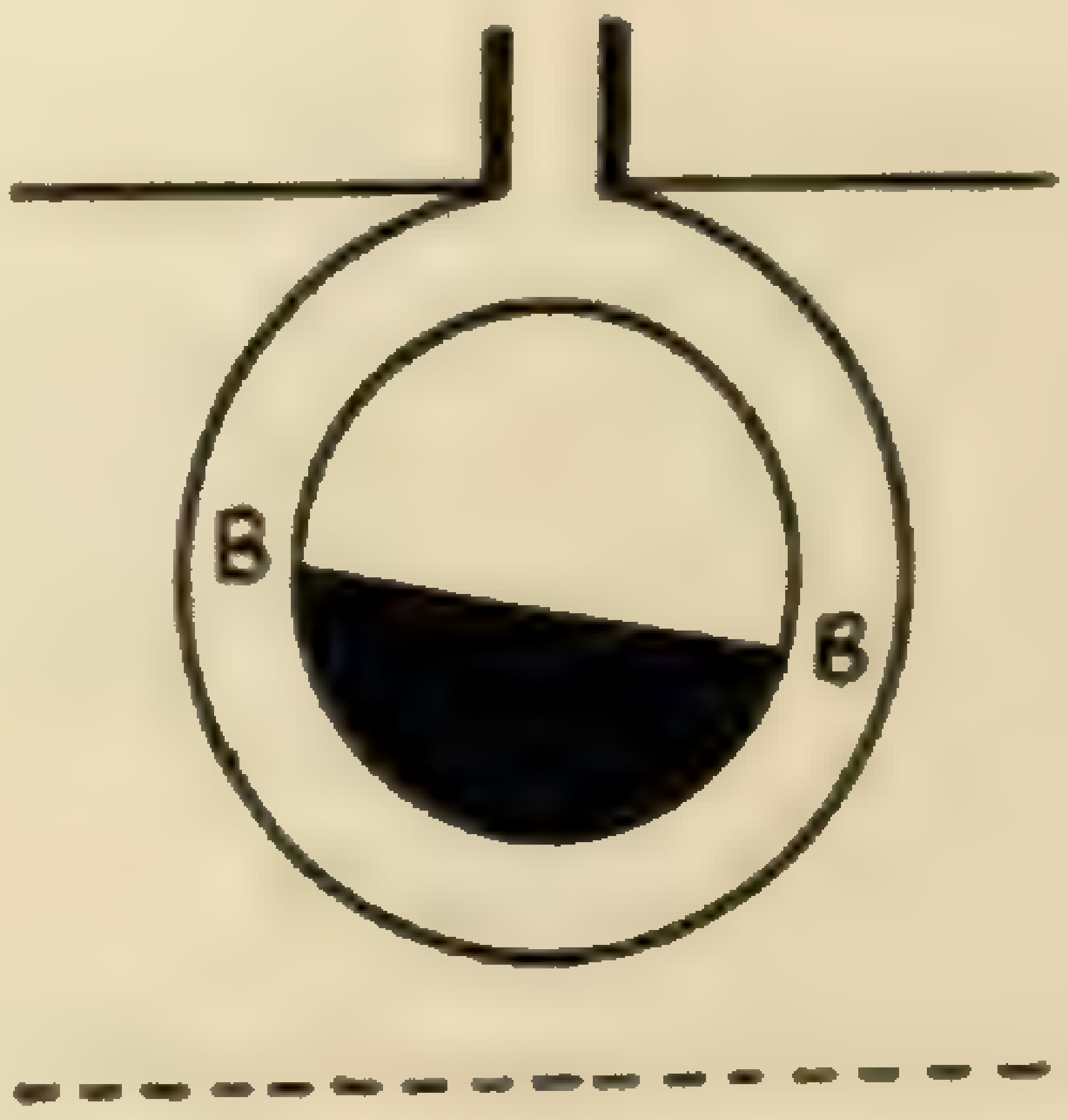

FIG. 10.—Embryo of Lycopodium.

Comparison of pteridophytic types of orientation and segmentation.—It seems to assist toward a clear conception of pteridophytic embryogeny to regard Equisetum as manifesting the primitive orientation and segmentation, and to interpret the other types as derivations, primary or secondary, from this fundamental bryophyte-like method. The Pteris and Lycopodium embryogenies may be considered as modifications due to adaptation. There are then at least these principal types:

A. Primitive orientation, *e.g.*, Equisetum.
B. Semi-inverted orientation, *e.g.*, Pteris.
C. Inverted orientation, *e.g.*, Lycopodium.

It will be noted that the type of Angiopteris must be connected with that of Equisetum. The hemispheres of the Angiopteris embryo lie in the original plane with reference to the substratum, the epibasal distally and the hypobasal proximally. Owing to the modified position of the archegone, on the ventral rather than on the dorsal side of the thallus, the epibasal hemisphere while retaining its primitive position with reference to the substratum comes into an entirely reversed position with reference to the archegone. The epibasal hemisphere now faces the base of the archegone instead of the neck. If it be accepted that the new position of the Angiopteris archegone as compared with the position of the same organ in the archetypal Anthoceros is an adaptation for protection it is apparent that class A above is easily divided into two subclasses as follows:

A. Primitive orientation.

1. Archegone in original position, *e. g.*, Equisetum.
2. Archegone in adaptive position, *e. g.*, Angiopteris.

To interpret the semi-inverted orientation of Pteris from the conditions in Angiopteris is possible if we regard it as a further adaptive modification. It may be conceived to be of advantage to the young embryo to grow through the least resistant tissues of the prothallium upon the ventral side of which it had originated. Any tipping of the egg so that the epibasal hemisphere should incline towards the growing point of the prothallium would subserve this end, and at the same time would more definitely place the absorptive hypobasal area in the most advantageous position with reference to the older, nutriment-containing portion of the gametophyte. Such an adaptive tipping forward of the epibasal hemisphere would be perpetuated, and at the same time might be accentuated until the change in position exceeded 90° as is the case if one compares Pteris with Angiopteris. The position, then, of the epibasal hemisphere of the Pteris embryo has an interesting suggestion concerning the phylogenetic history of the prothallium. Clearly the delicate almost unilamellar prothallium of the Polypodiaceæ offers slight resistance even if an embryo were to penetrate it directly with its cotyledon or stem-apex. Therefore it seems reasonable to regard the semi-inverted embryo as suggesting that the ancestral prothallia were much thicker, and that the habit of tipping forward dates from the time of thick prothallia. This is precisely in accord with many other bits of evidence all of which bear toward the same conclusion. And, *pari passu*, the position of the embryo in Trichomanes, suggesting as it does the reduced character of the filamentous prothallium, renders it difficult to conect the Hymenophyllaceæ directly with the bryophytes, as was the custom of the older pteridologists.

There is naturally no difficulty presented by the embryogeny Marsilia, nor by that of the closely related Pilularia or of the t distant Salviniaceæ. In all of the Hydropterideæ the semi-verted leptosporangiate fern embryogeny persists, except that e angle of variation from the original position is here quite xactly 90°. This perpendicular position of the basal wall may e in some way an adaptation to heterosporous conditions, and ay be connected with the positions of the nursing foot and of e emergent cotyledon and stem-apex. At any rate, it charac-terizes Isoetes, as explained above, and may be said to be the ark of all heterosporous pteridophytes of which the embryo is t provided with a suspensor. Two subclasses, therefore, may be defined under class B above:

B. Semi-inverted orientation.
  1. Sequence of segmentation planes normal, *e. g.*, Pteris.
  2. Sequence of segmentation planes abnormal, *e. g.*, Isoetes.

In the case of a plant so strongly isolated as is Iscetes specu-ation is scarcely profitable in an attempt to explain the origin the perpendicular basal wall. It may have been derived m either an Equisetum-like or Angiopteris-like, or even eris-like ancestral form. Certainly it is of all pteridophytic pes the most disconnected, as it is in some respects the most culiar. Whether the original tip-to-one-side began to charac-ize its embryo because a resistant prothallial mass lay between e embryo and the outer world, or because homosporous con-tions were gradually changed to heterosporous, and the nutri-ent supply and the megaspore wall exerted an influence upon e position of the young hemispheres, in any case the position st be regarded as one of adaptation. Just how the adaptive sition arose in this plant will possibly never be certainly sug-ested.

The inverted egg of the Lycopodinæ is very easily explained, far as the nature of the adaptation is concerned. Plainly enough the use of the suspensor or foot-homologue is to push the epibasal hemisphere into the center of the prothallium where the food-supply will most abundantly and symmetrically surround the developing segment. But to explain in any reasonable way how this remarkable inversion of the egg originated is quite another matter. The archegone in Lycopodium may be regarded as occupying a dorsal position on the thallus as in the case of Anthoceros. The Lycopodium prothallium, as seen in a primitive type like that of *Lycopodium cernuum*, not modified by adaptation to saprophytic nutrition, is comparable with an Anthoceros thallus, not only in the origin of the sexual organs but in the vegetative tract also. Yet it is inconceivable, I think, how an egg developing after the manner of an Anthoceros egg should invert itself in the archegone, convert its foot into a suspensor, and develop from its abnormally oriented epibasal cell the stem-axis and an adventitious nursing and absorptive tract. The inverted position of the Lycopodium egg cannot then be regarded as a primitive modification of the Anthoceros conditions. Rather would it appear that between the Anthoceros embryogeny and the Lycopodium embryogeny some other type had intervened.

It is possible, though no doubt extremely speculative, to refer the inversion of the Lycopodium egg to a double displacement, under adaptive conditions, of the archegone in the ancestral forms. While the archegone was situated on the ventral side of the prothallium the tipping of the embryo took place as in the ancestors of the Polypodiaceæ; following this the archegone worked back to the upper surface of the prothallium carrying the egg in its derived position. As the archegone returned, in successive generations, more and more to the ancient dorsal position, the embryo adapted itself to the most favorable position for nutrition and subsequent development, and when heterospory originated, the Selaginella type, in which the embryonic epibasal tract is immediately thrust into the center of the spore by the elongation of the primitive foot area, came into existence. Such an epibasal area of the embryo so placed must have early begun the development of an adventitious "foot" and root.

PHANEROGAMIC ORIENTATION AND SEGMENTATION TYPES.

All segmentation types among flowering plants, with the possible exception of that manifested by the extraordinary plant *Ginkgo biloba*, are referable to class C. Various secondary ecologic modifications have arisen, the most remarkable being the meroblastic segmentation in Coniferæ, the free-nuclear segmentation in the Gnetales — a phenomenon ecologically comparable to the free-nuclear origin of female prothallial tissues in Selaginella or to endosperm origin in most seed-plants — and the reduction of the suspensor, as in Pistia, Listera, Cypripedium, the Mimoseæ and Hedysareæ among others. It is not possible, however, to name any suspensorless flowering plant embryo except that of *Ginkgo biloba*, in which the absence of suspensor is not plainly and unmistakably a secondary adaptation. In Ginkgo alone is there a suggestion that the embryogeny belongs to the general fern type rather than to the lycopodineous. Other well-known old and new facts about Ginkgo should be considered in this connection but will here be passed over without further notice.

GENERAL CONSIDERATIONS.

Adaptive phenomena in reproductive tracts.—Unquestionably, like all other organs of the plant, those concerned with reproduction are more or less exactly adapted to their environment. It is true they are less plastic than the organs of the vegetative tract, and hence do not show the epharmonic characters so variously as stem, root, and leaf structures may. For this reason they are quite universally, by modern as by ancient taxonomists, employed as the landmarks of phylogeny, not easily shifted by transitory outward influence. Yet form and structure not primarily connected with their special functions may be imprinted upon then and developed in them. Special positions are assigned them under outward stimulus, and their structure, shape, size, attitude, and behavior may all come to have some definite relation to the *melange* of forces and substances that surround them. Compare, by way of illustration, the almost globular form of the spermary in Anthoceros or Dendroceros, growing under a pressure exerted by the cellular roof of the schizogenetic cavity in which the organ develops, with the elongated cylindrical spermary of Polytrichum situated upon its short pedicel in the axil of a bract of its "inflorescence." The shape of the one differs from that of the other not on account of different reproductive specialization but purely because molded by lateral pressures while the other is subjected to vertical. Again a similar reaction to outward conditions is to be observed in the convexity anteriorly of the so-called "neck" of the Polypodium archegone. Evidently enough this curved cylinder, differing morphologically as well as ecologically from the straight true neck of a moss archegone, is a response in form to its acquired ventral position upon the prothallium and to the forward growth of the prostrate sexual plant. The convexity may be regarded as a purely adaptational phenomenon determined by a group of conditions among which are the growth habits of the prothallium, the ventral position of the archegone, the extension of the "neck," and the resistance and friction of the substratum.

The primitive position of the sexual organs seems more intimately reproductive in its significance, than adaptational. That is, the position upon the plant-body of the rudimentary egg-maturing or sperm-maturing cell is determined by the conditions of accurate reproductive functioning, and not until considerable organs are evolved do the purely adaptive changes become important. The well-known and closely related plants Œdogonium and Bulbochæte, from their simplicity are suggestive. In Œdogonium, which consists of unbranched filaments, the egg-cells are intercalated between vegetative cells. In Bulbochæte, however, where branching is common, distal-proximal specialization makes itself felt, and the oogonia and antheridia are disposed terminally upon the branches, bringing them to the general sur-

e of the thallus where interference of closely packed branches
not hinder the egg-seeking, locomotive movements of the
rms. Together with this definite peripheral location of the
xual cells arises the need for protection of them from injurious
acts of all sorts and sharp bristling chætæ are developed.
In many Hepaticæ by invagination, and in Musci by envelop-
nt with bracts, the sexual organs are protected, and the
osure due to their morphologically peripheral position is modi-
or almost completely negatived. In Anthoceros the pro-
tive instinct results in the habit of developing the spermaries
actually closed cavities, not to be opened until the sperms
quite mature. Such derived positions while adaptational in
truest sense must be admitted to have important effects upon
reproductive rank of the organs or organisms in question.

Primitive reactions of segmenting eggs to their environment.—The
necessity that confronts a plant egg is that its position be
as to insure fecundation. That this may take place it is
ssary that the egg should be protected against harmful
ences, but should be exposed to the ingress of the sperm.
er fecundation it is necessary that the embryo should be pro-
ed and nourished and that it should, with the least waste of
ter or of energy, develop into a functional sporophyte. The
ction of a sporophyte may be briefly defined as the manu-
ure of as *many* and as *certainly germinable* spores as possible.
er such necessities the eggs are at first peripherally disposed
such protective layers about them as may have been
eloped and maintain this general position until spermatozoid-
ndation is abandoned, passing over through the Ginkgoales
Cycadales to pollen-tube fecundation.

The primitive segmentation-types as seen in Riccia may have
inated under direct stimulus by the force of gravity, as has
n suggested, but very early the direction of the basal wall
ame fixed with reference to the archegone axis and thereafter
d be changed only in course of extended evolution. The
al-proximal specialization of the archetypal embryos, bring-
into existence an epibasal as distinguished from a hypobasal

hemisphere, was an immediate consequence of the two conditions already mentioned, viz., transverse segmentation and peripheral position of the archegones. The persistence of the function of sporogeny in the epibasal hemisphere cell-descendants, and the disappearance of this function from the hypobasal tract is a most natural division of labor, and in each area improvements for reproduction and for absorption have been steadily evolved. By the relations of the young embryo to the parent prothallium and by the ancestral relations, orientation is determined. This is an adaptive phenomenon.

Kienitz-Gerloff[30] in a general article suggests, without having considered, however, a very full series of forms, that torsions (Drehung) may explain the oblique position of the Pteris epibasal segment as compared with that of the mosses, seeming to propose a spontaneous shifting of the plane of segmentation. This explanation I am unable to accept for the whole group of positions seems to be clearly adaptive. In the paper cited, Kienitz-Gerloff gives four diagrammatic longitudinal optical sections of embryos illustrating his idea of lateral torsion. This paper is of interest also from its ingenious though faulty determinations of homologies between Bryophyta and Spermatophyta, in quite the manner of the older school of embryologists.

SUMMARY.

1. The orientation of the plant-egg is at bottom a phenomenon of adaptation.

2. The conception of a basal wall is founded upon facts of phylogeny so profound that it is necessary to recognize that wall as basal which separates morphologically distal from morphologically proximal regions. The first wall formed may or may not be the basal wall.

3. Three principal types of egg-orientation are recognized: the *primitive* or bryophytic, characteristic also of Equisetum and Angiopteris; the *semi-inverted*, characteristic of Isoetes and the

[30] Ueber den genetischen Zusammenhang der Moose mit den Gefässkryptogamen und Phanerogamen. Bot. Zeit. 34: 705. 1876.

tosporangiate ferns; and the *inverted*, characteristic of Lycopodinæ and Spermatophyta.

4. The origin of the primitive type is in adaptation to the ripheral position of the archegones and to the plane of the substratum; the origin of the semi-inverted type is in adaptation to rived archegonial positions and resistance of prothallial areas, terfering with the direct normal growth of the embryo; the gin of the inverted type is in adaptation to repeated archegonial displacements and nutritive qualities of prothallial areas jacent.

5. The phylogenetic sequences derived from such an ecological investigation of embryos do not materially differ from those derived by a study of pure morphology.

University of Minnesota.

A CONTRIBUTION TO THE LIFE HISTORY OF THE PONTEDERIACEÆ.[1]

WILSON R. SMITH.

(WITH PLATES XIX–XX)

THE following investigation of *Pontederia cordata* was begun in the winter of 1897 as supplemental to a course in the special morphology of monocotyledons, under the direction of Dr. John M. Coulter. In the following summer, for purposes of comparison, I collected and studied material of *Eichhornia crassipes*. This is, so far as I know, the first examination of the gametophyte generation of any of the Pontederiaceæ. While the results, as might be expected, do not show any wide deviation from the usual series of events in monocotyledons, they have a value as indicating the extent of variation within a given order, and, in the case of Eichhornia, within a given species.

I wish here to acknowledge my indebtedness to Dr. Coulter for criticisms and valuable suggestions:

EICHHORNIA CRASSIPES.

MICROSPORES.

Fig. 30 represents a cross section of one of the youngest anthers I obtained. The tapetum is a distinct layer of small cells closely adherent to the spore mother cells, and often wedged in among them. Outside the tapetum are usually five layers of wall cells, the innermost of which appears always to disintegrate before the tapetum gives any clear signs of collapse. It is well known that in their later stages the tapetal cells of anthers are likely to become binucleate. Such a condition I have never found in a single case either in Eichhornia or in Pontederia. In the ripe anther there are, as usual, two layers in the wall, the ner of which has the characteristic reticulate thickenings of an endothecium.

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[1] Contributions from the Hull Botanical Laboratory. IX.

The mother cells are very large in comparison with the sur- nding cells. About the time they break apart and become unded, there is a very considerable increase in size. The hromatin assumes a beaded structure and the nucleus enters to the synapsis stage, which has been frequently described in other cells. The chromosomes, when first distinguishable, are ick and irregular, and lie scattered about in the nuclear space. hen arranged in the equatorial plate they have become more gular in outline and can be counted readily. The number is xteen (*fig. 32*), and the same number appears in the second ision (*fig. 35*). This is the reduction number. Although I ave not been able to count with certainty the chromosomes in e ordinary vegetative nuclei, I have ascertained the number to be not far from thirty.

Successive stages in the two divisions which end in the forma- n of the microspores are shown in *figs. 31–36a*. The divisions, common in monocotyledons, are successive, each daughter forming a wall about itself before the second division. So as observed, the nuclei resulting from the first division do enter into a resting condition. Very frequently they have nucleoli, and in such cases there are numerous bodies in the oplasm which stain like nucleoli (*fig. 34*). These bodies also be seen in the cytoplasm even when a distinct nucle- s is present within the nuclear membrane.

The usual arrangement of the tetrads is shown in *fig. 36* (*cf.* and *35a*), but such a grouping as *36a* is quite common.

As the microspores continue to enlarge they assume an ellip- dal shape. The generative and tube nuclei, very unequal in e, first appear when the flowers are about one-third grown; their origin from the primitive microspore nucleus I did not ceed in observing. The cytoplasm about the small genera- e nucleus is organized into a clearly outlined spindle-shaped , which becomes longer and longer as the microspore matures, its ends thin out into whip-like filaments (*fig. 40*). Its cytoplasm at the same time becomes highly granular (*figs. 40, 41*).

Another peculiarity of the microspores is the frequent occurrence of a division of the tube nucleus (*figs. 41, 41a*). It is impossible to regard either of the large nuclei of *fig. 41* as a sister of the generative nucleus. The latter is set apart within a separate cell quite early in the history of the microspore, and keeps a constant outline and appearance whether or not the third nucleus is present. Furthermore, the two free nuclei are too large to be so explained, and are alike in every particular, having all the characters by which the tube nucleus is usually distinguishable. Each has a prominent nucleolus, and shows an erythrophilous reaction in staining with haematoxylin and erythrosin, while the generative nucleus has no nucleolus, very abundant chromatin, and cyanophilous staining.

So far as I know, a division of the tube nucleus has been recorded only by Dr. Chamberlain[2] of this laboratory in the case of *Lilium Philadelphicum*, where its occurrence is rare. In Eichhornia, however, fully half of the mature pollen grains examined exhibit this peculiarity. The fate of these tube nuclei, and whether or not there is a division of the generative cell in the pollen tube, I did not succeed in determining. In longitudinal sections through the style pollen tubes were easily seen traversing three central canals, but almost always they showed marks of disintegration. Since Eichhornia does not set seed in our latitude, and there are apparently no abnormal structures in the embryo sac, it is probable that the division of the tube nucleus is due to pathological conditions in the pollen grains, and the failure to produce seed should be ascribed to the same cause.

MEGASPORES.

The youngest flowers obtained had the carpels already fused in such a way as to contain three loculi, and in each of these two longitudinal ridges run along the central axis. These ridges are the six placentæ. The only sign of the ovules at this time erceptible is the undulated outline of the placenta as seen in ngitudinal section (*fig. 1*). In older flowers the placentæ ave become distinctly papillate. The dome-shaped prominences shown in *fig. 4* are the young ovules. They are not rranged in regular rows, but are scattered so that every cross ection runs through two, three, or four to each placenta.

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[2] Life history of Lilium Philadelphicum. BOT. GAZ. 23:423–430. 1897.

At this time, or a little later, the archesporial cell is first apparent. Its nucleus is larger and less deeply stained than those of he surrounding tissue, while its cytoplasm is more dense and tains more deeply, especially with erythrosin (*fig. 5*). As the vule enlarges the archesporial cell divides unequally by a periclinal wall into an outer primary tapetal cell, and a larger primary sporogenous cell (*fig. 6*). The primary tapetal cell may emain undivided, but usually it divides into two by an anticlinal wall. The plane of division is either parallel to the axis of the ower, as in *fig. 7*, or at right angles to this axis, as in *fig. 9*. The apetal cells at once begin to lose their characteristic staining, and before their final disappearance are distinguishable from the ther cells of the hypodermal layer only by their position. If, owever, the primary tapetal cell does not divide, it retains its taining reaction more or less persistently to the last. The axial row of which the archesporium is the terminus also divides into two rows (*fig. 7*).

The further course of development of the primary sporogenous cell may be along two entirely different lines, which lead however to the same result, viz., the formation of a row of four megaspore mother cells, of which only the lowest one is fertile. These two series may be compared with those figured in Strasburger's *Angiospermen und Gymnospermen* for *Tritonia aurea* and *Anthericum ramosum* respectively. In the one case the primary sporogenous cell gives rise at once by successive divisions to a row of four cells, of which the lowest is always much the largest *figs. 8* and *9*). In the other case, most common in Eichhornia, the elongation of the ovule is accompanied by an elongation of the primary sporogenous cell without division of the latter (*figs. 11* and *12*). The nucleus also enlarges and invariably remains at the apex. Some idea of the relative length of time during which this state of things continues may be gained by comparing the integuments of *figs. 7* and *8* with *10* and *11*.

The subsequent divisions in the elongated sporogenous cell take place in quick succession. I have obtained a very large number of karyokinetic figures of these divisions, for since Eichhornia is peculiar in having all the flowers of a spike in pretty nearly the same stage of advancement, a single spike may yield upwards of two thousand ovules all of nearly the same age. The first spindle is in the apex of the cell and the division is very unequal (*fig. 12*). There is no uniformity in the order in which the succeeding divisions occur. Sometimes the upper cell divides first, sometimes the lower; more rarely, as in *fig. 13*, they divide simultaneously. The spindle in the upper cell is almost always obliquely placed (it may even be transverse), and it is doubtful if cell division is ever completed or even a cell plate formed. The division in the lower cell is also unequal, so that the lowest cell of the four, the fertile mother cell, is from the very first quite as large as the three sterile ones together (*fig. 13*). From a study of a large number of cases similar to *figs. 14* and *15*, I have been led to believe that the four mother cells when formed in this way are seldom, if ever, separated by walls.

All shades of transition between the two lines of megaspore development described above may easily be found even in the same flower. Thus *figs. 11, 12, 13, 16, 17* and *18* are all from the same ovary. *Fig. 17* shows a case in which the first division of the primary sporogenous cell has taken place when it is about half grown. In *fig. 16* it will be seen that after the first division only the lower cell has lengthened and divided, and, though a division of the upper cell has begun, this has been stopped by the encroachment of the two cells below.

The three sterile mother cells, and after them the tapetal cells and other cells in the apex of the nucellus, are rapidly absorbed by the growing megaspore, which soon comes to abut directly against the epidermis. In the absorption of ese cells there is no appearance of crowding; their walls break wn and their protoplasm becomes continuous with that of e megaspore (*fig. 24*). Before the complete absorption of e tapetal cells the nucleus of the megaspore, situated about e middle of the cell, divides into two (*fig. 24*). The lower f of the megaspore at this time ceases to grow, while the per half widens out and assumes the shape shown in *figs.* -27.

The division into micropylar and antipodal groups of four nuclei ows in the usual way without any regular time order. *Fig. 25* ws an embryo sac with four nuclei, *fig. 26* with eight nuclei, 27 fusion of the polar nuclei. The position of the definitive eus is always near the place where the embryo sac con-cts into the narrow basal portion. This nucleus is large, has very large, clear nucleolus, and is connected with the wall of e sac by strands of protoplasm. The fusion of the polar lei certainly occurs before pollination, for I have found the on accomplished in a flower whose perianth was not yet closed. That this act is not dependent upon the entrance of e pollen tube is proved very conclusively in *Caltha palustris*, ere I have observed sterile ovules through whose thickened ls no pollen tube can pierce, yet whose embryo sacs always ch the seven-nuclear stage. In Eichhornia, also, the embryo c always reaches the mature condition, in which, as we have en, most of the pollen tubes break down without penetrating the micropyle.

The antipodals of Eichhornia are evanescent, staining feebly m the first, and rarely with definite walls. Their nuclei do divide either directly or by mitosis.

The egg apparatus has the usual arrangement. The syner-s are provided with striated "filiform" tips and a prominent uole. The egg is relatively small and appears to be slung the bases of the synergids (*figs. 28, 29*).

I have found a pollen tube reaching to the embryo sac in one case, and that is represented in *fig. 29*. The single eus in the tip of the tube is probably one of the male nuclei, or possibly it is the generative nucleus itself, with which it agrees in size and staining. Its deep blue color is in strong contrast to the red of the synergids and oosphere, and of the tube nuclei of the microspores.

Since no embryos are formed the contents of the embryo sac sooner or later disorganize, always in this order: antipodals, synergids, oosphere, definitive nucleus. The definitive nucleus persists long after the other constituents of the embryo sac have disappeared. In a few instances a small number of free endosperm nuclei were found, and in one case these had arranged themselves into an incomplete parietal layer, but no cell formation of the endosperm was observed. Whether fertilization had been effected in these cases I could not make out, but the egg which was still intact had made no progress toward the development of an embryo. The coincidence of the usual failure of the pollen tube to penetrate to the oosphere with the infrequency of a division of the definitive nucleus lends weight to the generally accepted view that the stimulus which induces this division is the act of fertilization.

INTEGUMENTS OF THE OVULE.

The beginnings of the integuments may be seen in *figs. 6–8.* About the same time there begins a bending of the ovule which checks the growth of the outer integument where it comes in contact with the funiculus. By the time such a condition is reached as that shown in *fig. 12* the ovule is completely anatropous. The integuments are each two cell layers in thickness, with the cells above the micropyle much the largest. The absent portion of the outer integument next to the funiculus is represented by a thin layer of empty cells.

CYTOLOGY.

Only a few additional remarks need be made. I have not found Eichhornia a favorable subject for the study of cytological phenomena. Oil cells and glandular cavities are abundant, and a mucilaginous secretion pervades the cells and interferes with the transparency of the stains. Delafield's haematoxylin and erythrosin, and, in ovaries isolated from the perianth, anilin-safranin and gentian-violet gave the best results. Numerous other combinations were tried, but all were more or less unsatisfactory.

A typical spindle of the first karyokinesis of the elongated megaspore mother cell is represented in *fig. 20*. The large fibers attached to the chromosomes are plainly seen to be composed of many delicate threads. On the other hand the fibrillar structure of the central spindle is less clearly perceptible.

Cytoplasmic radiations about the poles occur in all good preparations and frequently the individual rays appear to terminate externally in large granules which stain like nucleoli. The chromosomes, 14 to 16 in number, were never seen to assume a V-shaped outline at any stage of the nuclear division. This statement holds good also for Pontederia, where by the use of iron-alum-haematoxylin a sharper definition of the chromosomes was secured.

All the preceding description of the spindle will apply equally to the divisions of the pollen mother cell.

The nucleus of the elongated sporogenous cell passes through a synapsis phase. If such a phase precedes the first division when that occurs early (as in *fig. 12*) I found no evidence of it. Perhaps no special significance can be assigned to the case shown in *fig. 18* (see also *figs. 22* and *23*), in which the two sporogenous cells whose nuclei are in synapsis have arisen apparently from the early division of the primary sporogenous cell. But if as has been suggested by some cytologists, synapsis occurs only in those cells in which a reduction of the number of chromosomes is going on, it would follow that when the primary sporogenous cell divides early without elongating, the chromosome reduction takes place in each of the resulting nuclei; whereas if the primary sporogenous cell elongates before dividing, the reduction is completed in the first nucleus.

PONTEDERIA CORDATA.

Longitudinal sections of very young spikes furnished a complete series for the study of the organogeny of the flower. The order of succession of the floral organs is acropetal (*fig. 42*) and need not be dwelt upon. Both in stamens and carpels traces of zygomorphy are very early recognizable.

The first indication of the ovule is a slight swelling on the inner wall of the lowermost carpel which is always the smallest (*figs. 43, 43a*). Normally but one ovule makes its appearance. I had expected to find the beginnings of ovules in each of the three loculi, but the facts are otherwise; out of the hundreds of ovaries sectioned I found but seven cases of a second ovule beginning, and no case of a second ovule reaching maturity.

The various stages from the differentiation of an archesporial cell to the completion of the embryo sac can be followed easily in the plate (*figs. 44–53*). A few comments only will be necessary here. The dividing wall of the primary tapetal cell runs always, so far as I observed, in the same plane with reference to the axis of the flower. There is reason to believe that quite often but three megaspore mother cells are formed. The lengthening of the ovule is effected in part by an elongation of the epidermal and tapetal cells and the other cells of the nucellar apex (*figs. 45–47, 48–52*). Later, however, those cells of the nucellus which have escaped destruction by the growth of the megaspore divide transversely (*cf. figs. 48* and *53*). The bending of the ovule is at first in a plane passing through the axis of the flower. Afterwards the funiculus twists through an arc of ninety degrees so that the ovule comes to lie as shown in *fig. 45*.

The embryo sac is very poor in protoplasm. A large central vacuole is formed and the cytoplasm is pushed to the wall as a very thin layer (*figs. 50–52*). The egg apparatus is remarkably small and is crowded against the micropylar end. The definitive nucleus lies low down in the sac, and is suspended by the strings of protoplasm trailed together by the polar nuclei (*cf.*

figs. 52 and 53). The antipodals here also are ephemeral, becoming very indistinct at the time of fertilization and soon after vanishing altogether.

The development of the microsporangia and microspores presents no unusual phenomena. As in Eichhornia the layer of cells outside the tapetum disintegrates before the latter and the tapetal cells are always uninucleate. *Figs. 57–65* represent stages in the division of the mother cells and growth of the microspores. Neither the generative nor the tube nucleus exhibits any of the abnormalities observed in Eichhornia.

The pollen tubes in their growth through the style are conducted along three canals which are each lined with a single layer of glandular cells (*fig. 55*). This layer is continued to the micropyle (*fig. 56*). The pollen tube entering the embryo sac was seen in several cases always passing between the synergids, one of which it destroys. Vestiges of the remaining synergid are still in view when the embryo has grown to such a size as in *figs. 67* and *68*. Apparently the pollen tube brings in two nuclei and its swollen end reaches almost, or quite, to the oosphere nucleus before these are set free (*fig. 54*).

A few stages of the young embryo are shown in *figs. 66–71*. The statement made in text-books that the roots of Pontederia have no dermatogen and hence no true epidermis applies only to the secondary roots. In the young embryo (see *figs. 70, 71*) a dermatogen is regularly cut off, and this in older embryos is continuous with the calyptrogen.

No attempt was made to study the cytology of Pontederia further than to determine the number of chromosomes, which is eight in the pollen mother cell, and fifteen or sixteen in the nuclei of the sporophyte tissue.

HETERANTHERA GRAMINIS.

A few ripe flowers of this species were sectioned and examined. In general appearance the ovule, with its integuments and embryo sac, bears a striking resemblance to those of Pontederia and Eichhornia. The synergids are longer and more prominent, however, and the embryo sac while smaller is more densely filled with protoplasm (*fig. 72*).

CONCLUSIONS.

I had hoped by a comparative study of closely related monocotyledons, and also of related dicotyledons, to be able in some degree at least to show how far the characters of the gametophyte generation could serve the purpose of indicating relationships among the larger groups of angiosperms. In this hope I have been disappointed. Those characters of the gametophyte generation in which, for example, Pontederia and Eichhornia agree, are characters which are common to hundreds of species of widely separated orders. The origin of the sporogenous tissue from the hypodermal cell terminating an axial row, the well-nigh universal occurrence of four megaspore mother cells of which but one matures, the usual cutting-off of a tapetal region which is finally absorbed by the growing megaspore, the division of the megaspore nucleus into eight free nuclei which are arranged in two groups of four each, the fusion of the polar nuclei to form a definitive nucleus which is the mother nucleus of the endosperm—these are the gametophytic characters of angiosperms in general. As soon as the comparison is pushed further we see that the differences between the two species in respect of the gametophyte are quite as great as often in other cases between unrelated plants, and the most striking resemblances, such as the shape of the ovule, embryo sac, and integuments are really sporophyte characters. If we were to draw up a tabular statement of the points in question in which Eichhornia and Pontederia agree, it would consist of two items: the ephemeral nature of the antipodals, which, however, is a characteristic of most monocotyledons; and the structure of the endosperm. Probably the female gametophyte of angiosperms has been so long parasitic upon the sporophyte that its only constant features are those of overwhelming phylogenetic importance, and its minor characters are readily variable in adaptation to the specific or generic differences of the sporophyte, or perhaps even to changes of environment. It seems, therefore, that the gametophyte characters cannot be of much value in assisting us to trace phylogenetic relationships among the angiosperms.

The irregularities which have been pointed out in Eichhornia may be correlated with its enormous power of vegetative reproduction. It has been propagated for years, without apparent loss of vitality, in the greenhouses and parks of Chicago, solely by this method; and no doubt this is its chief means of increase in the rivers of Florida and South America, where it has become a serious hindrance to navigation. The variations in the megaspore series are interesting, since they suggest how the megaspore of Lilium may have arisen from a type which had normally a tapetum and four megaspore mother cells. Let the change in Eichhornia go but a step further, let the nuclei which fail to form cells about themselves cease altogether to appear, and we should have a primary sporogenous cell passing without division into an embryo sac. Loss of the tapetum, as apparently occurs in *Hemerocallis fulva* by the same process (see the figures in *Angiospermen und Gymnospermen*), would result in the well-known habit of Lilium, where the archesporial cell develops directly into the embryo sac.

THE UNIVERSITY OF CHICAGO.

EXPLANATION OF PLATES XIX AND XX.

The plates have been reduced to ten twenty-sevenths of their original size. The magnifications given are those of the original drawings.

PLATE XIX.

Eichhornia crassipes.

FIG. 1. Longitudinal section of young ovary showing placenta. × 80.

FIG. 2. Cross section of an ovary of the same age as *fig. 1*. × 125.

FIG. 3. One of the placentæ of *fig. 2*. × 1300.

FIG. 4. Cross section of an older ovary. The cross indicates the position of the ovule which is shown in *fig. 5*. × 125.

FIG. 5. Longitudinal section of young ovule with archesporial cell. × 1300.

FIG. 6. An older ovule showing the primary tapetal cell (*t*) and primary sporogenous cell. × 1300.

FIG. 7. Ovule with primary sporogenous cell and two tapetal cells. × 1300.

FIG. 8. Ovule with two tapetal cells and two cells derived from division of the primary sporogenous cell. × 1300.

FIG. 9. Apex of nucellus with four mother cells. × 1300.

FIG. 10. Ovule showing primary sporogenous cell elongating. × 1300.

FIG. 11. Ovule with elongated primary sporogenous cell still undivided. × 825.

FIG 12. First division of the primary sporogenous cell. × 825.

FIG. 13. Second division in the megaspore series. × 1300.

FIGS. 14 and 15. Apex of nucellus with four megaspore mother cells. × 825.

FIGS. 16–19. Irregular development of the megaspore mother cells. × 825.

FIG. 20. Mitotic figure of first division of elongated primary sporogenous cell; cytoplasmic radiations about one pole. × 2000.

FIG. 21. Synapsis phase of the nucleus of the elongated primary sporogenous cell. × 2000.

FIGS. 22 and 23. The upper and the lower nucleus, respectively, of *fig. 18*, both in synapsis. × 2000.

FIG. 24. Apex of the nucellus with embryo sac after completion of first nuclear division. × 1300.

FIG. 25. The same after completion of second nuclear division. × 825.

FIG. 26. The same after completion of third nuclear division. × 625.

FIG. 27. Lower end of an embryo-sac showing the three antipodals, and fusion of the polar nuclei. × 1300.

FIG. 28. Embryo sac ready for fertilization. × 825.

FIG. 29. Apex of the embryo sac with pollen tube, striated synergids, and oosphere. × 1300.

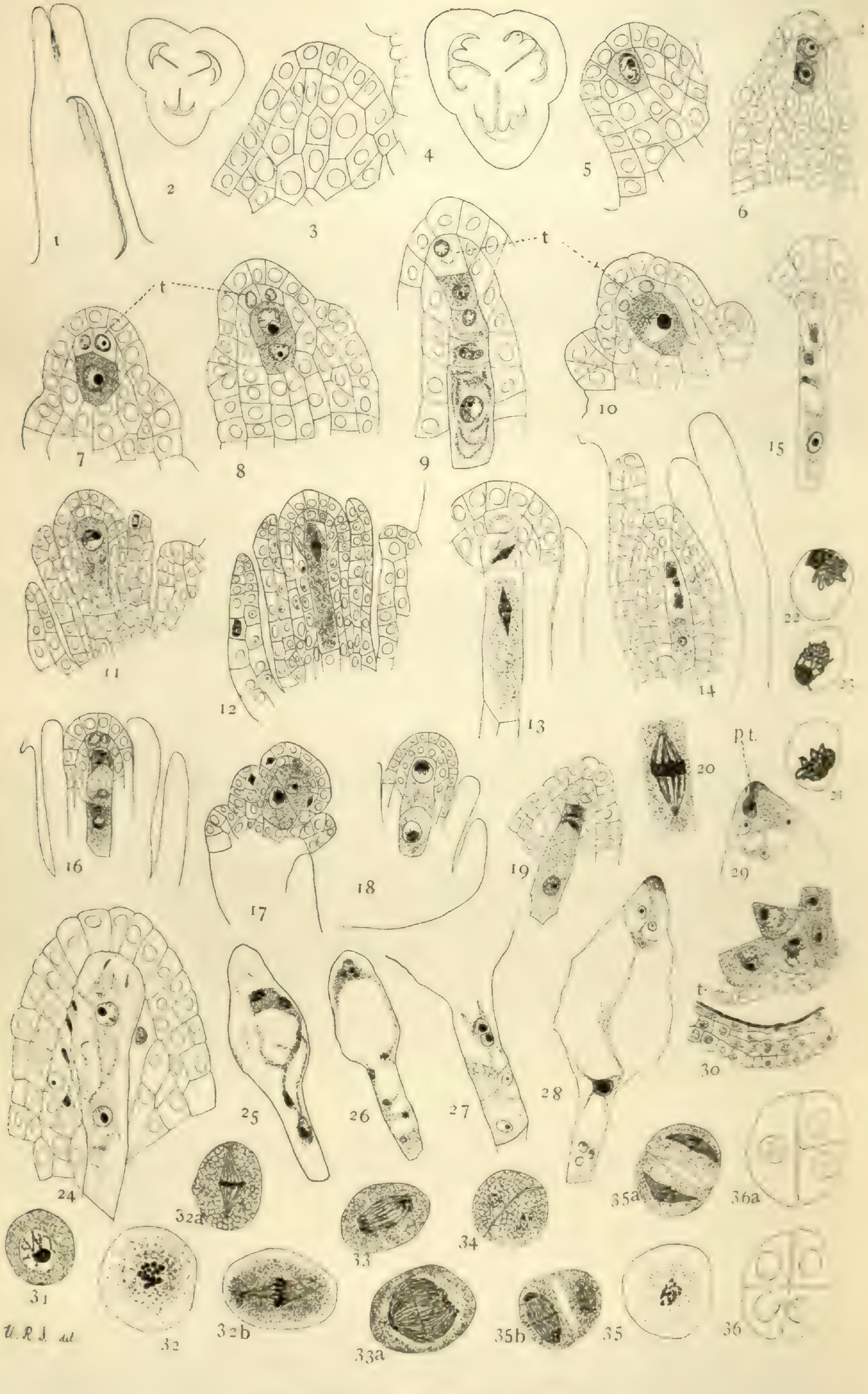
FIG. 30. Part of cross section of anther; *t*, the tapetum. Outside the tapetum a layer of disorganized cells may be seen. × 825.

FIG. 31. A single rounded pollen mother cell with its nucleus in the prophase stage. × 1300.

FIGS. 32–36*a*. Stages in the divisions of the pollen mother cell. *Fig. 32* shows the chromosomes in the equatorial plate of the first mitosis; *fig. 35* in the equatorial plate of the second mitosis. *Figs. 32 a* and *35* × 1550; the others × 1300.

PLATE XX.

FIG. 38. A microspore showing first organization of generative cell (*g*). In this and the following figures the tube nucleus is denoted by *t*. × 1300.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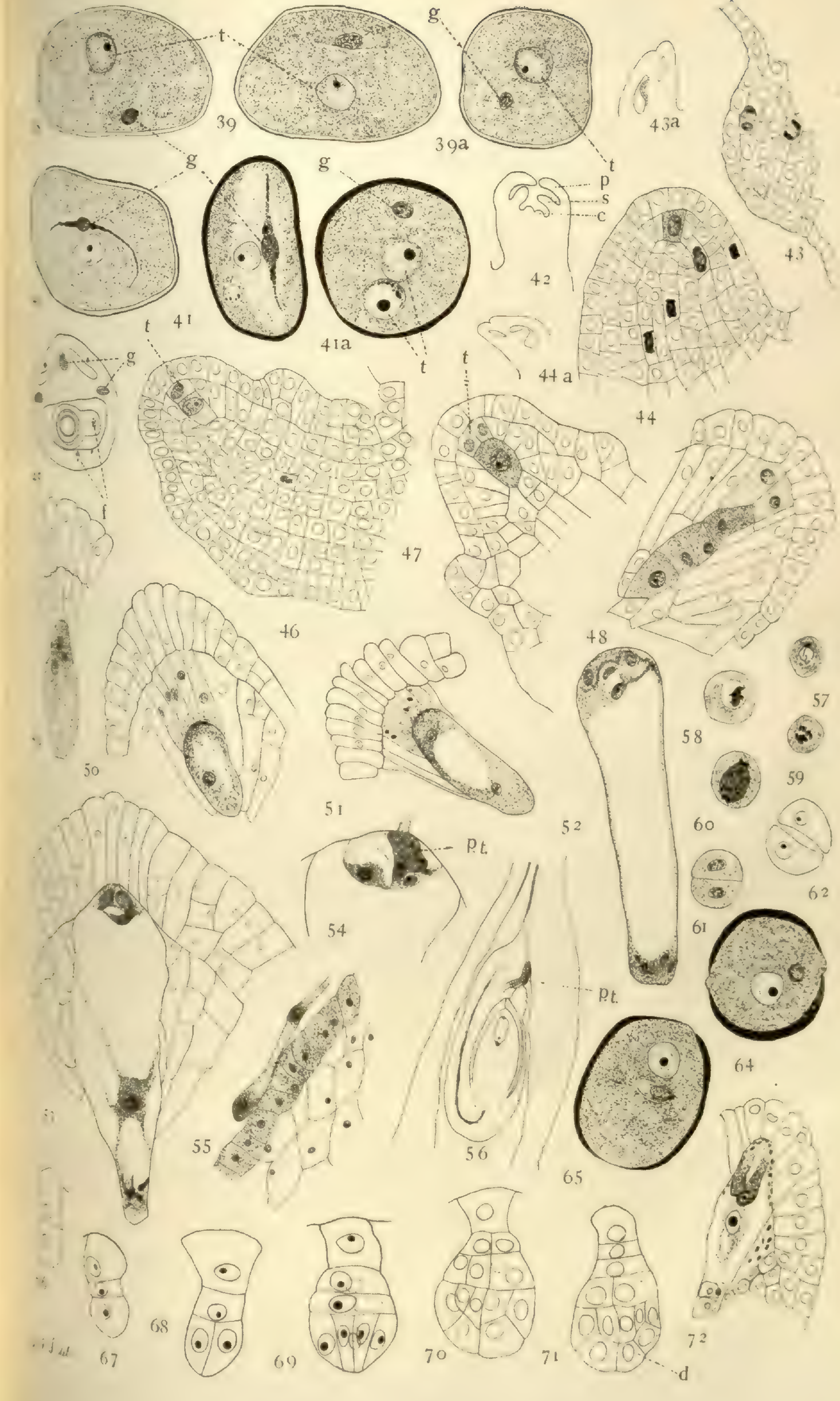
SMITH on PONTEDERIACEÆ.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SMITH on PONTEDERIACEÆ.

Fig. 39. Longitudinal section of an older microspore with generative cell and tube nucleus. × 1300.

Fig. 39*a*. Cross section of microspore of same age as *fig. 39*. × 1300.

Fig. 40. Ripe microspore. × 1300.

Fig. 41. Longitudinal section of ripe microspore, with generative cell and two tube nuclei. × 1300.

Fig. 41 *a*. Cross section of a similar microspore. × 1300.

Pontederia cordata.

Fig. 42. Longitudinal section of young flower; *p*, perianth, *s*, stamen, *c*, carpel. × 125.

Fig. 43. Ovule before the differentiation of the archesporial cell. × 1300.

Fig. 43*a*. Longitudinal section of ovary to show the relation of the ovule to the carpels.

Fig. 44. Young ovule with archesporial cell. × 1300.

Fig. 44*a*. Longitudinal section of ovary to explain *fig. 44*.

Fig. 45. Cross section of ovary, semi-diagrammatic; *f*, vascular bundles, *g*, glandular cavities.

Fig. 46. Young ovule with tapetal cell (*t*) and primary sporogenous cell. × 1300.

Fig. 46. Young ovule. The primary tapetal cell has divided into two. × 1300.

Fig. 48. Apex of nucellus with four megaspore mother cells. × 825.

Figs. 49 and 50. Encroachment of megaspore upon the sterile mother cells. At this time both integuments have grown beyond the apex of the nucellus. × 825.

Fig. 51. Embryo sac with two nuclei. × 825.

Fig. 52. Embryo sac with eight nuclei. × 825.

Fig. 53. Embryo sac ready for fertilization. × 825.

Fig. 54. Apex of embryo sac with pollen tube. × 1300.

Fig. 55. Longitudinal section of part of style, showing pollen tube traversing a cavity lined with glandular cells. × 825.

Fig. 56. Longitudinal section of ovary showing ovule, conducting tissue, and pollen tube (*p. t.*). × 125.

Figs. 57–62. Stages in division of microspore mother cell. × 1300.

Fig. 59. Chromosomes in equatorial plate of first mitosis of microspore mother cell. × 1300.

Figs. 64 and 65. Mature microspores. × 1300.

Figs. 66–71. Stages in the early growth of the embryo; *d*, dermatogen. × 1300.

Heteranthera graminis.

Fig. 72. Embryo sac ready for fertilization. × 1300.

THE GROUPS OF ANGIOSPERMS.[1]

A. ENGLER.

[IN the form of a supplement[2] to Parts II, III, and IV of *Die Naturliche Pflanzenfamilien*, Dr. Engler has presented a comprehensive review of the taxonomic divisions of spermatophytes. In it he has made important alterations in the sequence and structure of the series as arranged and delimited in the original work. In the light of results obtained since the publication of the earlier parts of the *Pflanzenfamilien*, a rearrangement has been made of which the following abstract from the author's "Erlauterungen" serves to give a general idea. Even the more important details have been rigidly omitted, and for a comprehensive grasp of the reasons for the changes the reader must be referred to the "key" which forms the skeleton of the supplement, and to the context.—EDS.]

The sequence of series and families is treated with special reference to the progressive steps which are manifested in floral structure, fruit and seed development, and differentiation of tissue.

Certain difficulties present themselves in the practical carrying out of such a scheme. It often occurs that within one circle of relationship a certain tribe has advanced in some particular direction, remaining latent in other directions, while the reverse may be true of other related tribes. In other cases it is doubtful whether certain lower stages are primitive, or whether they have arisen through reduction.

Eichler has recognized the so-called apetalous families of dicotyledons as haplochlamydeous, or naked-blooming, instead of abortive, and has placed them at the beginning of dicotyledons. To these I have added Piperales, Proteales, Santalales, and Aristolochiales.

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[1] Abstract of translation prepared by Dr. Edwin B. Uline.

[2] ENGLER, A.: Übersicht über die Unterabteilungen, Klassen, Reihen, Unterreihen und Familien der Embryophyta siphonogama. Leipzig: Wilhelm Engelmann. 1897.

Before entering upon a discussion of the sequence of series the monocotyledons and dicotyledons, I wish to speak of the gnostic importance which is being laid upon the development the pollen-tube in the ovule, and the structure of the ovule h respect to the development of the integuments. In the first w series of Archichlamydeæ (*i. e.*, the Piperales, Verticillatæ, agales, Juglandales, Myricales, Salicales, Urticales, Proteales, ntalales, and Aristolochiales) the pollen-tube and the ovules w relations which never occur elsewhere in angiosperms. s for the chalazogamy of Treub, the investigations of Nawahin and others have greatly depreciated its importance from e standpoint of classification, and of late more importance has en laid upon the peculiar conditions which occur in the Santaceæ and Loranthaceæ in the development of ovules and bryo sacs, as set forth by Van Tieghem, who distinguishes a anerogamous division "Inovulées" to which the Loranthaceæ nd Balanophoraceæ belong, and another division "Innucellées," hich about corresponds to our Santalaceæ.

For my part, I do not see sufficient importance in either of se sets of characters to justify the establishment of subdivins of the first rank. Nor in the fact that in the Loranthaceæ e embryo sac is developed within the tissues of the carpel do scern peculiarities which justify setting these plants apart as osed to the remaining dicotyledons and monocotyledons. an only regard them as dicotyledons which, like all other tyledons, are opposed in many respects to monocotyledons, which in the development of the ovules show certain depares of their own. We can no more found a higher systematic ision on the more or less complete development of the ovule an on the presence of endosperm and perisperm, or on the re or less advanced development of the embryo of the ther-plant. Indeed, if the gymnosperms stand in close rela- to the pteridophytes, since normally developed ovules with cellus and integument occur in the gymnosperms, it is natural assume that the peculiar development of ovules in the Santaes is merely a phenomenon of reduction.

But it is a striking fact that these departures occur in several of those families which were formerly known as apetalous. This seems the more reason why all these families should occupy a lower place in the system of dicotyledons. The manner of fertilization and the development of the embryo sac is here not so fixed as in the other dicotyledons. The Proteaceæ, also, which I have placed much lower than Eichler, show a striking departure from other dicotyledons in that the number of cotyledons may reach even eight.

MONOCOTYLEDONS.

Among the nonocotyledons those series in which typical achlamydeous flowers occur represent the earliest stages of development. These are the Pandanales, Helobiæ, and Glumifloræ. Of these the Pandanales are most primitive, because of indefiniteness of floral parts, and the spiral arrangement of stamens. Whether the Helobiæ or the Glumifloræ stand next in order is difficult to decide. Owing to the great instability prevailing in the Helobiæ, I have preferred to let them precede the Glumifloræ, and have left the Gramineæ and Cyperaceæ together in Glumifloræ.

Common to the three series Principes, Synanthes and Spathifloræ is the appearance of a floral envelope, which in some cases is suppressed by the more vigorous development of the spathe.

Several subseries under the Farinosæ must be set apart; notably the Flagellariineæ, which do not affiliate closely with any other family. The subseries Enantioblastæ is characterized by its orthotropous ovules, while the remaining Farinosæ have anatropous ovules.

Most of the Liliifloræ belong to the subseries Liliineæ. I have regarded the Juncaceæ as a separate subseries, Juncineæ, being intermediate in the structure of their albumen between the Farinosæ and the Lilliifloræ. Likewise I have separated the Iridaceæ as subseries Iridineæ, basing it upon the leafy development and division of the style branches, as well as upon the position of the leaves.

I believe it a misconception to regard the Scitamineæ as direct descendants of the Liliaceæ or of the Amaryllidaceæ. Though the Scitamineæ do resemble Dracæna and Cordyline, stronger characters argue against deriving them from the Liliifloræ, viz., the formation of endosperm and perisperm, the smooth exine and thick intine of the pollen grains, the presence of simple and complex starch grains in the albumen.

The Microspermæ comprise the Burmanniaceæ and Orchidaceæ, whose relationship to each other is based solely upon the numerous small ovules and the parietal placentation. The Burmanniaceæ are like the Orchidaceæ in that they attain a degree of zygomorphism which is found in few monocotyledons, and a careful review of characters shows no possible connecting link between Orchidaceæ and the Liliifloræ. The Microspermæ may fall, therefore, into the two subseries, Burmanniineæ and Gynandræ.

DICOTYLEDONS.

The dicotyledons as here presented show many departures from Eichler's system. One of the most essential changes is the breaking up of the series of Amentaceæ and the interpolation at various places of the miscellaneous families designated by Eichler as Hysterophyta. That the Amentaceæ of Eichler do not represent one circle of relationship has become apparent after close investigation of the ovules and the processes of fertilization. That the establishment of the Hysterophyta was only provisional is evident from their long-known variability as to the gynæceum.

The Ceratophyllaceæ are taken out of Eichler's Urticinæ and placed near the Nymphæaceæ; the Piperaceæ are separated from the Polygoninæ; the Droseraceæ, Sarraceniaceæ and Nepenthaceæ are separated from the Cistifloræ or Parietales as Sarraceniales; the Passiflorinæ are brought under the series Parietales; the series Terebinthinæ and Tricoccæ have been entirely broken up and their separate families referred partly to the Geraniales, partly to the Sapindales or to the Æsculinæ, the limitation of these latter two series being governed by the orientation of the ovules, a scheme used also by Bentham and Hooker ; the series Frangulinæ or Rhamnales has been restricted to the families Rhamnaceæ and Vitaceæ, while the Aquifoliaceæ, Celastraceæ and Hippocrateaceæ are put in Sapindales. I follow Pax and Baillon in placing the Pittosporaceæ near the Saxifragaceæ. I have united the series Saxifraginæ, Rosifloræ, and Leguminosæ into one series, *i. e.*, the Rosales, since the natural affinity of these groups is beyond all doubt. The Proteaceæ have been excluded from the Thymelæales and placed more toward the beginning of the system near the Santalales, the remaining families being added to the Myrtifloræ or Myrtales.

Of the Sympetalæ the two series Tubifloræ and Labiatifloræ are united ; the Aggregatæ on the other hand are broken up, and the Valerianaceæ together with the Dipsacaceæ placed in the Rubiales, and the Compositæ in the Campanulatæ.

Both subclasses of dicotyledons, Archichlamydeæ and Sympetalæ, are retained, although sharp distinctions between them do not exist. The guiding characters for the disposition of the series under the Archichlamydeæ are chiefly the development of the perianth, the floral axis, and the arrangement of floral parts, but consideration has been given also to the make-up of the ovules in so far as the Casuarinaceæ are concerned, distinguished by numerous megaspores, and for which alone the series Verticillatæ has been made, and is placed at the beginning of the Archichlamydeæ.

Of the remaining series, those which have no perianth must take the lowest place, namely, first the Piperales, then the Salicales, then the Myricales, in which several bracts near the flowers often take the place of a perianth. The Myricales contain only the Myricaceæ, which with the Juglandaceæ I had placed formerly under the Juglandales.

The Balanopsidales with the family Balanopsidaceæ represent an isolated series which occupies a very low place by reason of the rudimentary perianth of the staminate flowers, and the bracteate envelope of the pistillate ones.

The series of Leitneriales with the Leitneriaceæ is doubtful, since we may have to do here with a reduced type. If such were once shown, then this family would come next to the Hamamelidaceæ, near the Rosales.

The Juglandales occupy a higher position, nearly always possessing a perianth, which in the pistillate flowers is coalescent with the carpels, giving rise to apparent epigyny. The Juglandales are further distinguished from the Myricales by chalazogamy, but whether this character is constant must yet be determined.

The Fagales show the same stage of progress as the Juglandales. Coordinate with the Fagales are the Urticales in which the Ulmaceæ precede the Moraceæ and Urticaceæ because of the occurrence of hermaphrodite flowers.

In the Proteales the perianth is sometimes green, but in the majority of cases it is petaloid, but a differentiation of calyx does not appear. This series is easily distinguished from the Santalales by its single free carpel with ventral placentation.

The Santalales, comprising the Loranthaceæ, Myzodendraceæ, Santalaceæ, Grubbiaceæ, Opiliaceæ and Balanophoraceæ, have their gynæceum made up of three (more rarely one or two) carpels, and for each carpel but one embryo sac is developed.

In the Aristolochiales the petaloid segments of the perianth become more or less coalescent, and the carpels are provided with an indefinite number of ovules and an inferior ovary.

The Polygonales form, in certain respects, the transition stage to the Centrospermæ, though the latter is characterized by the presence of perisperm.

Although it is mentioned above that certain series are morphologically further advanced than others, and that on the other hand certain series as the Fagales and Urticales occupy the same morphological stage of advancement, yet each of these series is to be regarded as an independent plant-group, which can in no sense be derived from any of the others. Nor is there any reason to suppose that any of these series constitute a point of divergence for the following series.

In the Centrospermæ heterochlamydy occurs frequently, though it does not yet dominate. The Chenopodiaceæ and Amaranthaceæ form one branch of the series, while the Nyctaginaceæ, Cynocrambaceæ, Batidaceæ, and Aizoaceæ together with the Phytolaccaceæ, in certain respects the center of development, form another branch. Of these the Nyctaginaceæ have reached a higher stage than the Chenopodiaceæ and Amaranthaceæ in that the simple corolla is made of petaloid coalescent segments. The Cynocrambaceæ and Batidaceæ form isolated types which, in common with Phytolaccaceæ, still retain one-ovuled carpels. The Phytolaccaceæ, having free or slightly united carpels, would occupy a low position, save for the appearance of heterochlamydy and cyclic flowers. Still a third subseries is formed by the Basellaceæ and Portulaccaceæ; a fourth by the Caryophyllaceæ.

Of the numerous heterochlamydeous series the first is Ranales, characterized by predominating apocarpy and hypogyny. It has preserved a strong tendency to the spiral arrangement of floral parts, but heterochlamydy is much more frequent than in the Centrospermæ, and zygomorphism occasionally occurs. At least four subseries are to be distinguished. The Nymphæaceæ and Ceratophyllaceæ form the first; the rather isolated Trochodendraceæ the second; the Ranunculaceæ, Lardizabalaceæ, Berberidaceæ, and Menispermaceæ, the third. This third subseries has a probable common origin very near the Nymphæaceæ. The fourth comprises the Magnoliaceæ, Lactoridaceæ, Anonaceæ, Myristicaceæ, Gomortegaceæ, Monimiaceæ, Lauraceæ, and Hernandiaceæ, all characterized by the presence of oil cells. I have named these subseries respectively the Nymphacineæ, Trochodendrineæ, Ranunculineæ, and Magnoliineæ. In the three larger, which are further advanced than Trochodendrineæ, there occurs the change from spiral to cyclical flowers.

Since in the Ranales the spiral arrangement, indefinite numbers of parts in andrœceum and gynæceum, and apocarpy all appear as dominating characters, it is clear that the other series diverge from the Ranales in various ways, some following one direction of development, some another.

The Rhœadales have long been recognized to be closely related to the Ranales, for the Papaveraceæ show analogies with the Nymphæaceæ in their mostly numerous stamens, and in the occasional occurrence of several (though united) carpels in the gynæceum.

The Sarraceniales furnish a parallel series to the Rhœadales. This series shows much in common in the arrangement of floral parts with the Nymphæaceæ and Papaveraceæ. The placentation in the Sarraceniaceæ is the principal character distinguishing the series from the Rhœadales.

I have considerably extended the Rosales, which very often have apocarpy and hypogyny or perigyny in common with the Ranales, but more often show syncarpy and epigyny. The series comprises the Saxifragineæ, the Rosifloræ, and the Leguminosæ of Eichler. We have never been able to discover a comprehensive distinction between the Rosaceæ and Saxifragaceæ; nor is there any dividing line between the Rosaceæ and the Leguminosæ sufficient to warrant putting them in separate series. It may seem strange that the Podostemonaceæ stand at the beginning of Rosales, but Warming has shown their connection with the Saxifragaceæ on the basis of floral structure. The Leguminosæ and the Connaraceæ are to be regarded sister-families of the Rosaceæ, since the families of Rosales are, as a whole, so nearly related that it is difficult to conceive of them under subsections. The Saxifragineæ, however, form a center of development, from which the Podostemonineæ branch in one direction, the Rosineæ in another.

In both the Geraniales and the Sapindales the cyclic arrangement of floral parts is complete, but the still imperfect union of the carpels is a ground for placing both series before the Malvales and Parietales. The two series may only be distinguished by the ovule characters. In the Geraniales the Geraniaceæ and the Oxalidaceæ are followed by the zygomorphous and oligomerous Tropæolaceæ. I have then followed with the Zygophyllaceæ, which occupy mostly the same plane as the Geraniaceæ but in the other direction they approach very near to the Cneoraceæ, Rutaceæ and Simarubaceæ. Since the Rutaceæ are intimately connected with the Simarubaceæ, Burseraceæ and Meliaceæ, it is possible to conceive of these families all together as Geraniineæ. Morphological advance in another direction is seen in the Malpighiineæ. It is expedient also to distinguish the Polygalineæ, Dichapetalineæ and Tricoccæ as subseries, which possess scarcely any surviving common features.

In the Sapindales, considering the entire organization, foliar arrangement and anatomy, we are forced to establish a large number of subseries. At the first are the Buxineæ, provided that the simple perianth is primitive rather than reduced. The Empetraceæ, Coriariaceæ, and Limnanthaceæ occupy similar rank in the character of perianth and the number of ovules, but are withal so distinct that each family must be regarded as the representative of a subseries. The resinous Anacardiaceæ may be regarded as an independent subseries coordinate with and opposed to the Celastrineæ and Icacineæ. The Sapindaceæ comprise the closely related Aceraceæ, Hippocastanaceæ and Sapindaceæ, and the Sabiineæ, Melianthineæ and Balsaminineæ. The setting apart of so many subseries shows there is no sufficient ground for the derivation of the more complex families of the series from the simpler.

The Rhamnales are now confined to the tetracyclic Archichlamydeæ with opposite stamens.

As in the Geraniales and Sapindales, there are to be found in the Malvales distinct or slightly united carpels, but in the latter case complete syncarpy prevails. I justify my letting the Malvales follow the Geraniales, Sapindales, and Rhamnales by the close relationship of the Elæocarpaceæ and the Chlænaceæ to the Parietales, within which the floral evolution has already reached very complicated floral types. The Malvales clearly show how a family may reach in certain directions a considerable stage of development, while in others it remains far behind. Conditions are present which show that the near related families of the series are coordinate and not serial; that they stand side by side, but have not proceeded one from another. The Scytopetalaceæ have a very uncertain position in the series.

As already indicated, the Parietales reach back in their affinities through their simpler families to the region of the Ranales. The Dilleniaceæ were also formerly reckoned with the Ranales, but they show affinities for the tropical families Eucryphiaceæ, Ochnaceæ, Caryocaraceæ, Marcgraviaceæ, Quiinaceæ, Theaceæ, Guttiferæ, and Dipterocarpaceæ, and I have brought them all together as a subseries, Theineæ. Another subseries, the Tamaricineæ, is made up of the Elatinaceæ, Tamaricaceæ, and Frankeniaceæ, which mostly inhabit temperate zones. The Fouquieriaceæ, which in the *Pflanzenfamilien* were reckoned with the Tamaricaceæ, are better separated as an independent family and subseries, on account of their gamopetalous corolla and oily albumen. The changes which have been made in this series are based chiefly upon the results obtained by Dr. Pritzel in his late studies of the seeds of Parietales. His data have great value in the determination of the genetic relationships. Such a series as the Parietales is not to be regarded as a single monophyletic circle of relationship, but as a complex of such circles, which, proceeding from various starting points, have either arrived in their evolution at the same morphological stage of advancement, or, like the subseries Flacourtiineæ, still show various stages of development.

The Opuntiales, with their spiral floral arrangement and tubular receptacle which encloses the syncarpous gynœceum, show quite a primitive floral type, essentially departing very little from that of many Nymphæaceæ. The only reasons for placing this series next the Parietales is that free carpels never occur in the Cactaceæ, that the placentæ are parietal, and the styles are united.

In the series Myrtifloræ and Umbellifloræ the envelopment of the gynæceum within the receptacle has become the rule, and, in contrast to the preceding series, the arrangement of stamens is constantly cyclic. In the Myrtifloræ perigynous and epigynous insertions prevail; in the Umbellifloræ only the epigynous occurs. The series Thymelæales, which formerly, following Eichler, I placed next to the Myrtifloræ, I now believe to be only a subseries of the latter. In those families formerly regarded as Thymelæales perigyny, tetramery, a tendency to apetaly, and a small number of ovules in the carpels prevail, but every one of these characters also occurs in the Myrtifloræ. The Halorrhagidaceæ and the Cynomoriaceæ I regard as representatives of an independent subseries, whose flowers show a most remarkable agreement with Hippuris. That the Umbellifloræ belong at the end of the Archichlamydeæ is certain by reason of their one-ovuled carpels and mostly reduced sepals. The close interrelationship of the three families belonging here is without question.

The opinion has often found expression that the Sympetalæ may be only monopetalous. This cannot be the case, and it is equally certain that the various series of the Sympetalæ are not to be regarded as a continuation of the Archichlamydeæ. When sympetaly arose in prevailingly archichlamydeal series, such sympetalous genera were naturally placed in archichlamydeal families. The subclass Metachlamydeæ or Sympetalæ thus comprises those families in which connate petals have become the rule. Just as the series indicates the stage at which certain genetic subseries have arrived, so the subclass Sympetalæ may be looked upon as a stage for morphologically further advanced series.

The Ericales and Primulales belong at the beginning of the Sympetalæ, for here distinct petals still occur, and two staminal whorls are typical, whereas in the remaining series, with the exception of the Ebenales, only one staminal whorl is developed.

The Ebenales are distinct from the Ericales in that the flowers are not obdiplostemonous, but diplostemonous or triplostemonous, or they may contain numerous stamens. They differ from the Primulales in the septation of the ovary, and from the remaining series in the possession of more than one staminal whorl.

The Contortæ are by no means to be sharply distinguished from the next comprehensive series, Tubifloræ. It is simply a question of differing tendencies of development. One subseries, the Oleineæ, with the families Oleaceæ and Salvadoraceæ, sometimes still possesses distinct petals. In the second subseries, the Gentianineæ, belong the Loganiaceæ, Gentianaceæ, Apocynaceæ, and Asclepiadaceæ, the first of which comprises genera which show characters common also to the three other families, but also contains genera which lean more toward the Tubifloræ and Rubiales. The Loganiceæ may thus represent an older type, from which the other families of Gentianineæ, and perhaps the Rubiales, have branched off.

The largest and most difficult series is the Tubifloræ, within which numerous families are separated from one another only by very poorly defined characters. Advancement takes place from those families with actinomorphous flowers and several-ovuled carpels to those with zygomorphous flowers and few-ovuled carpels. But in a part of the Tubifloræ the tendency to claw-formation especially prevails, and in these the carpels contain only a few, often only two ovules. In close connection with these Tubifloræ are the Hydrophyllaceæ and Convolvulaceæ. Therefore, I distinguish first the subseries Convolvulineæ, with the Convolvulaceæ and the Polemoniaceæ. The Borragininеæ constitute the second subseries, of which the Hydrophyllaceæ possess capsules and may be regarded as the starting point for those Borraginaceæ which possess claw-fruit. The subseries Verbenineæ joins on to the Convolvulaceæ by having in the Verbenaceæ and the Labiatæ the ovule with the micropyle directed downward. Then come the numerous families which group themselves about the Solanaceæ and Scrophulariaceæ in which placentæ with numerous ovules mostly occur. These I have grouped together under the subseries Solanineæ. Between them and the Convolvulineæ are the Nolanaceæ. The Acanthineæ belong near the Solanineæ, yet owing to the great number of peculiarities of the Acanthaceæ, and in spite of certain points in common with the Bignoniaceæ and Scrophulariaceæ, I have ventured to separate them as a subsection.

Some botanists might prefer to put the Plantaginales under the Tubifloræ, but in that case, on account of the upturned micropyle, they would form a special subsection near the Borraginineæ. I have placed them next the Tubifloræ as an independent series.

The epigynous Rubiales and Campanulatæ form naturally the close of the Sympetalæ. In both series we find actinomorphy and capsules with numerous ovules; in both series the further stages of zygomorphy and reduction are reached.

In the series Rubiales, to which, following Fritsch and Hoeck. I have added the Valerianaceæ and Dipsacaceæ, I do not regard division into subseries as necessary. Both the families just named join quite closely to the Caprifoliaceæ. We can only venture to offer a special subseries for the peculiar Adoxaceæ.

In the Campanulatæ, on the contrary, the Cucurbitaceæ occupy a special place, and form the subseries Cucurbitineæ. The Campanulaceæ must be regarded as the remnant of a trunk from which the others have branched out. That the Compositæ occupy the last place in the system can scarcely any longer be doubted.

It is evident that the several series are independent form-groups which have developed mostly side by side, but not from one another. In only a few cases do the series stand so near together that a common origin must be supposed. The same is true also of the subseries and of the families within the subseries. Even within the families themselves it is mostly not possible to determine a common starting point for the subfamilies. In spite of all the uncertainty that prevails regarding the origin of series, it is absolutely certain that parallel development has very often taken place, and the view that in the development of the siphonogams from the asiphonogams a great number of parallel series came into existence from the beginning seems tenable. The oldest monocotyledons and dicotyledons, like the living conifers and other gymnosperms, possessed no floral envelope, but an indefinite number of stamens and carpels, which were either spiral or whorled within the same tribe. Then from the bracts preceding these sexual phyllomes, or from the lowest stamens, the perianth was developed. In a few scattered tribes of monocotyledons and dicotyledons these lower stages are still to be found, but in others, where cyclical arrangement and definite numbers prevail, they have disappeared. We cannot know whether or not the latter possessed spiral arrangement of members originally; indeed, it is not necessary that this should have been the case, for it is possible that at the very first formation of series, forms with spiral and also with cyclical arrangement should have arisen. Thus fixation of number could have appeared early in the one and late in the other.

Nägeli believed that every tribe has proceeded from early types with spirally arranged floral phyllomes. If this were true, then the Orchidaceæ, for instance, would be the oldest of monocotyledon types, and the Umbelliferæ and Compositæ very old types of dicotyledons, for they would have gone through the most modifications. However, in my opinion, there is nothing against the view that cyclical arrangement arose in certain tribes from the very beginning. In the most of these tribes and series fixation of number probably appeared very early, and of these many afterward suffered modifications by reduction of particular members or multiplication of others. In those series in which wind-pollination prevailed, Pandanales, Glumifloræ, Principes, Fagales, a highly developed corolla, having no particular value, stood no chance of transmission to the generations following. Modifications could only take place in other directions, particularly in the reduction of the number of members, which in certain Glumifloræ, Piperaceæ, Salicaceæ, Urticaceæ, and Chenopodiaceæ has reached its extreme limit. Other modifications may also occur in the form of complex inflorescence. But where the perianth is petaloid and insect-pollination has become established, finally zygomorphy follows, and thereby reduction, which attains considerable importance in such families as the Pontederiaceæ, Leguminosæ, Philydraceæ, Rutaceæ, etc. Although in the reduction of petaloid and heterochlamydeal flowers I have ascribed much influence to insect-pollination, yet I must contend against the opinion that the formation of petaloid structures has been induced by insect-pollination. The appearance of these structures in various and widely separate series can at first only have been conditioned upon external influences. In countless culture plants we see that by supplying richer nutrient materials and more light the formation of petaloid structures notably increases, and that sepals and stamens become petaloid. But it is to be conceded that insect visits may contribute to the fixation of such characters when once acquired, but they alone could not accomplish this were the physiological causes of color supply not permanently furnished to the succeeding generations. The development of color material in the floral phyllomes may also be retarded by its transference to the subtending bracts or to other more favored flowers in the inflorescence. In the Spathifloræ the development of the flowers remains in the background, owing to the manifold capabilities of the spathe, while the petaloid bracts of Dalechampia in the Euphorbiaceæ produce the same result. The inner flowers in the inflorescence of Hydrangea are retarded by the strong petaloid development on the periphery. On the other hand, insect-pollination is decidedly instrumental in the reduction of flowers, more than in the special petaloid development of particular perianth-whorls. For it is quite clear that when the insects continually prefer in their visits those stamens or carpels most conveniently situated, those not used must gradually become functionless. Here it is not a question of production of certain materials, as in the case of the petaloid perianth, but only of restriction or suppression of already existing structures at the expense of other more vigorous ones.

Among the monocotyledons the Scitamineæ and Microspermæ surpass all others in the production of petaloid floral parts, in the prevalence of zygomorphy, and in the reduction of the andrœceum. In the dicotyledons these conditions appear in a great number of series.

BERLIN.

BRIEFER ARTICLES.

THE WILD FLOWERS OF CUSHING'S ISLAND, MAINE.

THE popular summer resort known as Cushing's island is a small island in Casco bay, a few miles from the city of Portland. Its greatest length is a mile and a quarter, and its shore line about five miles. In shape it is roughly triangular; the base of the triangle, or the back of the island, is towards the open ocean, while the front looks towards the mainland and Portland city.

A rocky ridge runs through the island close to its seaward side, projecting as "The Point" at one extremity, and forming White Head cliffs at the other. This ridge, covered with a stiff growth of spruce and fir trees, forms a very efficient protection to the rest of the island from the storms and cold winds from the ocean. The large hotel known as the Ottawa House is situated on one of the highest parts of this ridge, and looks over the landward half of the island, which is low and rather level, with grassy meadows and sandy shores.

On account of this conformation of the ground, there is an unusual diversity of natural conditions. Hence, in spite of the small size of the island, there is an astonishing variety of wild flowers to be found; so that the writer was able to gather in the course of a short summer's vacation more than three hundred distinct species, and there are doubtless many others which escaped his attention.

The first place to which a visitor to the hotel would naturally turn his attention is the woods which lie immediately behind it. As intimated before, these woods are formed almost entirely of spruce and fir trees, and this fact alone will enable any botanist to picture them in his mind. Such woods are always cool and shady, even on the hottest summer day, with dark foliage overhead and the pleasant odor of balsam in the air. Little underbrush is formed owing to the dense shade of the thick branches, but the ground is covered with a soft carpet of moss and fir needles. Everywhere are to be seen the delicate graceful fronds of the wood-ferns, the dark leaves of the wintergreen

(*Gaultheria procumbens*), or the bunch-berry (*Cornus Canadensis*) with its red berries. There are other forms more difficult to find, but which will amply repay a search for them. Few of our native flowers can be compared with the twin-flower (*Linnæa borealis*), whose slender creeping vines and tiny pink bells sometimes completely cover the ground and scent the woods for yards around. In certain nooks may be found clusters of lady's slippers (*Cypripedium acaule*), one of the most beautiful of our orchids, or the white waxy flowers of the shin-leaf (*Pyrola rotundifolia*), or the delicate enchanter's nightshade (*Circæa alpina*).

In certain parts of the woods there are low places, where the ground becomes swampy. Here the undergrowth becomes more profuse. The magnificent flowering ferns or osmundas, growing to a height of four or five feet, often form dense brakes. The curious Jack-in-the-pulpit (*Arisæma triphyllum*) abounds, and rarer forms such as the rein-orchis (*Habenaria bracteata*) and the ragged fringed orchis (*Habenaria lacera*) are found; while in the soft moist swamp-moss are growing more delicate plants, such as the sweet white violet (*Viola blanda*), the small bed-straw (*Galium trifidum*), and many others.

Some years ago a fire occurred on the island, and burned off a large tract of woodland along the White Head road, between the hotel and the Ross cottage. Light and sunshine having been let in on the ground plants of all kinds seem to have invaded the place and to be struggling for its possession. A new growth of poplar and white birch is springing up and promises to take the place of the former dark conifers. At present, however, another group of plants is in the ascendancy, for this clearing is the home of the berries for which Cushing's island is famous. Every summer numerous parties of berry pickers visit the island and return laden with fruit, but their depredations seem to have little effect in exhausting the supply. Raspberries and blue berries are the most abundant, but there is no lack of blackberries, gooseberries, and huckleberries. The plants also are very varied, each week during the summer showing a new assortment. Bushes of elder (*Sambucus Canadensis*) and viburnum (*Viburnum cassinoides*), covered with white blossoms, are perhaps the most showy. The great willow-herb (*Epilobium angustifolium*) is common, as is usual on all burnt ground. Other plants that are particularly noticeable are golden ragwort (*Senecio aureus*), sarsaparilla (*Aralia hispida*), hawkweed (*Hieracium scabrum*), cow-wheat (*Melampyum Americanum*), and ladies' tresses (*Spiranthes gracilis*).

Leaving the wooded ridge that shelters the island from the ocean, e come next to the landward side. This part of the island is more evel and is occupied by meadows, with the cultivated fields belonging o the farm in the center of the island. It is here that the greatest bundance of summer flowers is to be found. In the spring violets and wild strawberries abound ; later on, the meadows are a blaze of yellow nd white from the buttercups and daisies which fairly cover the ground; ll later, when the hay has been gathered in, and the fields have been eft bare by the mowing machine, every stony place, hedge or thicket adorned with masses of goldenrods and purple asters. Besides these lants, which are in such abundance as to form prominent features in e landscape, there are scores of old friends to be found by every road-de, along the fences, and among the hay. Here are clovers, ever-tings, wild rose, sweetbriar, silkweed, thistles, mustard, evening rimrose, and a host of others too numerous to be enumerated here. ne point of interest might be mentioned in connection with these eadow plants. A botanist looking at the list of the species that cur would probably be struck by the fact that very few of them are ative American plants. Cushing's island has been inhabited for two undred and fifty years, and during this time many plants have been ntroduced, either intentionally or accidentally, through their seed eing mixed with that planted on the farm. Other seeds have proba-y blown or floated across from the mainland. These foreigners have ourished and driven out of the fertile places most of the native plants ; o that if one wishes to study true American plants, he must go to the oods, rocks, marshes, and out-of-the-way places. As an illustration this it may be remarked that no less than fifty-eight different kinds English, European, and tropical plants are to be found growing in e fields on Cushing's island.

Although the woods and meadows furnish the greater part of the ild flowers of the island, a visiting botanist would probably be more nterested in the plants of a less promising locality, namely, those ound on the rocky shores and sandy beaches. While the flowers ready mentioned may be seen anywhere in the northern states, those f the shores are peculiar and only to be found along the Atlantic sea-oard. They grow in the most unlikely localities, flourishing in the efts of the rocks and in the dry sand down to and even below the gh-tide mark. Few of them have showy blossoms, though the flow-rs of the beach pea (*Lathyrus maritimus*) and the Scotch lovage (*Ligus-cum Scoticum*) are exceptions to this rule. More curious and characteristic forms are the spiny saltwort (*Salsola Kali*), or the cactus-like samphire (*Salicornia herbacea*). Most of them have fleshy succulent stems and leaves, enabling them to store up the scanty moisture for a time of drought. This is well seen in the case of the sea blite (*Suæda linearis*), the sea rocket (*Cakile Americana*), and the seaside plantain (*Plantago maritima*). Other interesting plants found in these sections are the seaside crowfoot (*Ranunculus Cymbalaria*), goldenrod (*Solidago sempervirens*), sea lavender (*Statice Limonium*, var. *Caroliniana*), spurge (*Euphorbia polygonifolia*), rush saltgrass (*Spartina juncea*), and sea sand-reed (*Ammophila arundinacea*).

Besides the localities already mentioned, there are several natural features of Cushing's island which are especially interesting from a botanical standpoint. At the front of the island are two small marshes, separated from the sea only by narrow sandy beaches. These marshes are partly covered with dense thickets of hazel and alder, but the open parts furnish many interesting forms. As is usual in marshy places, reeds and sedges abound, with bulrushes, bur reeds, and irises. Certain parts of the marshes are carpeted with the delicate trailing vines of the cranberry (*Vaccinium macrocarpon*). Another plant of great interest found here is the sundew or flycatcher (*Drosera rotundifolia*), whose small leaves may be seen with all their glistening bristles spread out, ready to entrap any unwary insect.

Another characteristic feature of the island is the part called Bayberry ridge. This is a low ridge or rather a rise in the ground, which presents a rather peculiar appearance owing to islands of bushes which are scattered over it. These little islands are formed mainly of bayberry, sweet fern, and juniper bushes, but mingled with them are other flowering shrubs, such as blackberry bushes, wild roses, and spiraea.

The island terminates towards the north in a precipitous cliff known as White Head. Here the rocks rise perpendicularly from the sea to a height of over a hundred feet. Even on the face of this frowning rock, exposed to all the winds and storms, with nothing but tiny crevices for their support, are seen some of the most delicate plants. Prominent among these is the wild columbine (*Aquilegia Canadensis*), whose red and yellow blossoms are a familiar sight in such localities. An equally pretty but less showy flower is the crane's-bill (*Geranium Robertianum*). The lion's foot (*Prenanthes Serpentaria*) and some slender ferns and grasses complete this little group of hardy cliff-dwellers.

Lastly, no account of the flora of the island would be complete without some mention being made of the famous willow grove, a group of fifty or sixty magnificent trees growing in a slight hollow above the bathing beach. These trees are probably a hundred and fifty years old, many of them have trunks eighteen or twenty feet in circumference, and none of them show any signs of decay. Taken as a whole, it is probably the finest willow grove in the New England states.

This too brief and imperfect account may serve to give some idea of the flora of Cushing's island. A botanist could wish for no better place in which to study the flora of the northern New England coast. —HAROLD B. CUSHING, *Montreal, Canada.*

NOTES ON THE BOTANY OF THE SOUTHEASTERN STATES. II.

DIERVILLA RIVULARIS Gattinger, Bot. Gaz. **13**: 191. 1888.—Fruiting specimens of this interesting Diervilla were collected August 24 and again October 5, 1897, on the rocky bluffs of Lookout mountain, Tennessee. Dr. Gattinger originally found the species in a similar station at Lula falls, on the Georgia side of Lookout mountain, and some six miles from the station of the material at hand.

CRATÆGUS COLLINA Chapm. Flora S. U. S. ed. 2. second suppl. 4. 1892.—A species very distinct, but confounded with *C. punctata* Jacq. *C. collina*, as it grows at Biltmore, N. C., is a small tree $4–5^{m}$ in height, and with a trunk diameter of 1^{dm} under favorable conditions, with gray spreading branches that are freely armed with rather stout chestnut-brown to gray spines. The flowers, which appear before any others of the genus, are about 2^{cm} in diameter, white and of a disagreeable odor: calyx divisions lanceolate, glandular, the tube pubescent: shoots, foliage, and corymbs appressed pubescent, becoming glabrous with age: fruit globose, about 1^{cm} in diameter, dull red: leaves obovate to nearly oval, $3–7^{cm}$ long, including the petiole, $2–5^{cm}$ wide, or a trifle larger on vigorous shoots, acute, finely but obtusely serrate and incisely lobed, the base narrowed into a short petiole. The range, though imperfectly known, is evidently from northern Georgia, Tennessee, and North Carolina to West Virginia and Missouri. From *C. punctata* the species may be separated by the fewer

(4 or 5 pairs) and less prominent veins of the leaves, shorter petioles. and more abruptly attenuate base of the blades, earlier time of blossoming, glandular calyx lobes, and smaller fruit.

Fraxinus Biltmoreana, n. sp.—A tree 10–18^{m} in height, the trunk not often over 3^{dm} in diameter; branches large and spreading; branchlets stout, the growth of the season softly and densely pubescent: leaves 2 to 3^{dm} long, oblong to oval in outline; leaflets 7 to 9, ovate to oblong-lanceolate, acuminate, sometimes falcate, rounded, attenuate or inequilateral at the base, entire or obscurely denticulate. dark green and slightly lustrous above, below whitened and from sparsely to copiously pubescent, especially along the veins; petioles and petiolules finely and densely pubescent to puberulent: samaras, which are borne in open pubescent to nearly glabrous panicles, large, 3.5 to 5^{cm} long, the wing about 6^{mm} wide and from two and a half to three times longer than the elliptical, unmargined, many-nerved body. Flowers not collected.

The species evidently bears about the relation to *F. Americana* L. that *F. Pennsylvanica* Marsh. exhibits to *F. lanceolata* Borck. From *F. Americana* the Biltmore ash may be distinguished by the velvety twigs and petioles, the clove brown buds and usually stouter branches and branchlets, and by the elliptical bodies of the large samaras.

The limits of the distribution of *Fraxinus Biltmoreana*, as now shown by specimens preserved in the herbarium, extend from the mountains of North Carolina (Biltmore herbarium, no. 4049, Biltmore, N. C., type locality), to northern Georgia (Dr. J. K. Small, near Toccoa, Habersham county, Ga.). It is very probable that the species will be found to occupy a much larger area when better known.

Disporum maculatum (Buckley) Britton, Bull. Torr. Club 15: 188. 1888.—Splendid examples of this rare species were collected on the slopes of Busbee mountain, Buncombe county, North Carolina. April 22, 1896, the blossoms just opening; and again, April 27, 1897. specimens with flowers fully expanded were gathered at Hot springs, Madison county, North Carolina. In these specimens, as well as in a mere fragment preserved in the Chapman herbarium from the latter locality and gathered in 1887, the stamens are longer than the segments of the perianth, the divisions of which are liberally sprinkled with small purplish dots, and the ovary is conspicuously white-woolly. The pubescence of the stems and leaves is coarser, and not so dense as on *D. lanuginosum* (Michx.) Nicholson, with which it not infrequently associates.

AMORPHA VIRGATA Small, Bull. Torr. Club **21** : 17. 1894.—In the mountains of western North Carolina *Amorpha virgata* is frequently represented, and, so far as I am aware, is the only species of the genus in the upland section of the state. It is found in considerable patches at elevations of $700-1000^{\mathrm{m}}$, instances of which are located near Round knob, McDowell county, and Busbee mountain, Buncombe county, forming coarse but attractive shrubs $1-3^{\mathrm{m}}$ high. The flowers appear at the stations given about the first of June, the fruit hanging until after the leaves have fallen.

Brauneria Tennesseensis, n. sp.—A hispid, perennial herb from a long and fusiform blackened root, $2-3^{\mathrm{dm}}$ high, bearing showy heads of purplish flowers in late summer: stems 1–several from the top of the root, simple or with one or two primary branches, papillose-hispid: leaves linear to linear-lanceolate, $0.5-1.75^{\mathrm{dm}}$ long including the petiole, $0.5-1^{\mathrm{cm}}$ broad, attenuate at the base, the apex usually acute, 3-nerved, papillose-hispid, especially along the margins: peduncle thickened upwards, sulcate angled, like the stem or more sparingly hispid, usually bearing one or two leaf-like bracts: heads $1.5-2^{\mathrm{cm}}$ high, conical, nearly as broad as high: involucre composed of lanceolate ciliate scales, thickened at the base: rays $2-3^{\mathrm{cm}}$ long, purplish, hispid on the lower surface, 2-cleft at the apex, the divisions mucronate: chaff rigid, carinate, pointed, longer than the disk flowers: achenes 4-sided, wing-angled on the longest side: pappus a narrow-toothed border with four prominent points corresponding with the angles of the achene.

Collected Aug. 19, 1897, just in flower, on a dry, gravelly hill near LaVergne, Tenn., and associated with *Grindelia lanceolata* Nutt.

B. Tennesseensis is closely related to *B. pallida* (Nutt.) Britton, from which it may be known by its smaller size, very hispid stems and leaves, longer and narrower achenes (which are prominently winged on the longest angle), by the later season of flowering, and the spreading scarcely drooping rays.

SOLIDAGO ULIGINOSA Nutt. Jour. Acad. Philad. **7** : 101. 1834.—Dr. Gray[1] pointed out that Nuttall probably had more than one plant in view when he described the above, and that there can be no doubt as to the one upon which the species was founded. As qualified in the *Synoptical Flora*,[2] *S. uliginosa* finds its southern limits in the mountains of Pennsylvania, but specimens that match northern material passing under this name were collected September 15, 1897, in the mountains of Macon county, North Carolina, at an elevation of about 1500^{m}. In this situation the plants were found close to the sides of the waterways that under ordinary conditions are kept moist by the liberal and usually evenly distributed precipitations. I am indebted to Dr. Small, of Columbia University, for much help and information regarding this material.

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[1] Proc. Am. Acad. 17 : 193. 1882.

CRATÆGUS TOMENTOSA **Chapmani**, nom. nov.—*Cratægus tomentosa microcarpa* Chapm. Flora, ed. 3. 139. 1897. Not *C. microcarpa* Lindl.—So far I have not seen the typical *C. tomentosa* in the south, and I agree with Dr. Chapman in recognizing the form with very small fruit as a well marked variety. Near Biltmore, N. C., *C. tomentosa Chapmani* forms a small tree 4–6^{m} high, growing usually in rich soil and attaining a trunk diameter of 1^{dm} or less. The branches are gray, and armed with slender spines: leaves 5–12^{cm} long (occasionally larger), broadly ovate, prominently veined, sharply serrate and incisely lobed, and from sparingly to densely pubescent beneath: corymbs many-flowered, leafy, bearing glandular, caducous bracts, and covered when young with fine, pale tomentum, which finally disappears: flowers small, 1.5^{cm} wide, ill-scented: calyx pubescent, the divisions lanceolate, serrate, acute: fruit sub-globose, 5–7^{mm} in diameter at maturity, bright red, long persistent.

Originally discovered on the banks of Silver creek, Floyd county, Georgia, by Dr. Chapman, whose name I have used in the new trinomial. The distribution is probably confined to the region of the southern Allegheny mountains.

CAREX OLIGOCARPA Schk. Riedg. Nachtr. 58. *f. 170.* 1806.—On May 26, 1896, in sandy soil bordering the Swannanoa river at Biltmore, N. C., material that matches specimens of *C. oligocarpa* from Vermont and Delaware was found in frequent patches. Dr. Chapman[3] admitted the species to the range of his work on the authority of M. A. Curtis, but I cannot at this time find any further notice of its distribution in the south.

[2] Syn. Flora 1^{2}: 151. 1884.

[3] Flora S. U. S. ed. 2. suppl. 661. 1889.

Carex juncea Willd. Enum. Pl. Hort. Berol. Suppl. 63. 1809.—Specimens from Roan mountain, Mitchell county, North Carolina, are frequently displayed in herbaria and the handbooks treating on the flora record no other stations, although Boott[4] extends the range to the mountains of North Carolina and Georgia. At the summit of Craggy mountain (2000$^{\mathrm{m}}$ elevation), Buncombe county, North Carolina, *Carex juncea* was found in abundance July 13, 1897, growing in dense tufts from the black, fertile soil characteristic of the high elevations of the region.—C. D. Beadle, *Biltmore, N. C.*

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[4] Ill. Gen. Carex 189. 1867.

OPEN LETTERS.

A MEXICAN TROPICAL BOTANIC STATION.

THE BOTANICAL GAZETTE during the past three years has agitated in its editorial columns and by the publication of open letters the establishment of a tropical botanical laboratory. The consensus of opinion seems to be that such a laboratory should be situated in Jamaica, which would be easily accessible both to English and American botanists. Jamaica has, without a doubt, many advantages over other localities in the western tropics. The late Professor J. E. Humphrey in a letter to the GAZETTE refers to the peculiar conditions which make Jamaica a suitable place for such a laboratory:

> As compared with many other parts of the tropics, the climate of Jamaica is exceptionally healthful, and it is remarkably free from poisonous animals. Its continental character makes possible a rich and varied flora, and within a few miles one may pass from the sea level to the summit of the Blue mountains, 7360 feet high. The island is a British colony, which means that life and property are secure, the roads fine, the language English. It is accessible by steamer at least once a week from either Boston, New York, Philadelphia, or Baltimore, and the principal points are now connected by railroad. There are on the island two interesting botanic gardens at Castleton and Gordon Town under the direction of Mr. Wm. Fawcett, Director of Public Gardens and Plantations, who would doubtless give such an enterprise every encouragement and much valuable aid.

All these advantages seem to point to Jamaica as the most suitable place for the establishment of such a tropical laboratory, where much needed botanical research can be prosecuted. Professor Goebel is quoted in the GAZETTE[1] as saying:

> It appears to me particularly desirable that the laboratory should be placed near a botanical garden, because of the greater number of plant forms available, besides the herbarium and library, as well as the opportunities for experimental culture afforded. Furthermore, another important condition would be the location of the laboratory as near as possible to the primitive forest.

However great the advantages of Jamaica may be for the study of tropical vegetation, it is advisable not to overlook other regions of the western hemisphere which are especially suitable for the botanical investigations which alone can be carried on in a tropical country. The writer wishes to make a plea for Mexico, not because he does not recognize the suitability of Jamaica, but because he desires to call the attention of American and English botanists to several Mexican localities with which he is personally familiar, having visited them in the summer of 1896.

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[1] 23: 208. 1897.

Orizaba.—Orizaba is a town of 15,000 inhabitants in the state of Vera Cruz, on the line of the Mexican railway, 82 miles from Vera Cruz, 181 miles from the City of Mexico, at an elevation of 4000 feet above the level of the sea. The town lies in a little valley surrounded by very fine mountains. The peak of Orizaba (17,356^{ft}), however, cannot be seen from the town, although within a half day's journey. The town is composed for the most part of low houses with red tiled roofs; it is crossed by two small streams and by the little river Orizaba (through a rocky ravine filled with tropical plants), all of which unite near by in the river Blanco. The region is especially rich in tropical orchids and epiphytes. The city is in close proximity to the *tierra caliente*, the *tierra templada*, and, on the sides of Mount Orizaba, to the *tierra fria*. A tramway extends from the station into the town, passing the doors of the hotels; another line extends to the pretty suburb Yngenio, and thence a little beyond to the Nogales station on the Mexican railroad. Of superb beauty and grandeur, affording fine botanizing ground, is the cañon of the Rincon Grande about three miles out of the town. Orizaba and the neighboring town of Cordoba (2000^{ft}) are easily reached by the Mexican railway from Vera Cruz after three hours' ride through grand and inspiring mountain scenery. Botanists from the central and eastern United States can reach Vera Cruz by steamer direct from New York, New Orleans, and Galveston. Botanists from the Pacific coast and from the Rocky mountain region can take the overland route from El Paso to the City of Mexico, and thence to Orizaba, passing across the interesting Mexican deserts and descending step by step from the elevated Mexican tableland in the *tierra templada* to Cordoba in the *tierra caliente*.

Jalapa.—Jalapa, reached from Vera Cruz and from the City of Mexico, also presents exceptional advantages for tropical botanical research.

It is, however, to neither of these places that the writer wishes to advert especially. It is to the little known and interesting region tributary to the town and seaport of Tampico on the Gulf coast. Tampico is too unhealthy for the establishment of a station there, although the region is of exceptional interest with the river Panuco and the Lago de Tamiahua giving access by canoes to the luxuriant tropical forest of the Gulf coast. If such a laboratory be established, it must be at sufficient elevation to have a salubrious climate. Such a place is found at a station on the Mexican Central railroad called Las Canoas, 144 miles distant from Tampico.

Las Canoas.—Las Canoas is situated in the beautiful basin-shaped valley of that name (3500^{ft} above sea level). The soil is a red clayey loam, and a stream, having its rise in a perennial spring, affords an abundant supply of clear and limpid water. Good water is a very important item to strangers in a tropical country, especially in Mexico, where the streams are polluted by the frequent washing of clothes along their courses. The Valley of Las Canoas is shut in from the surrounding country by high hills, and is especially well situated for the establishment of a tropical laboratory. The air is clear and bracing, and food is easily obtained. Easy of access to the deserts on the table land above by the daily trains which run on the Mexican Central railroad to San Luis Potosi and thence to Aguas Calientes, the locality is especially well situated for botanizing. From Las Canoas by means of the railroad toboggan, or by train, one can descend through the grand and impressive Tamasopo cañon into the tropics. Mr. Pringle[2] has described the characters of the region in such an interesting pen picture, that the writer cannot refrain from quoting him at this point :

> Gliding beside the stream of purest water issuing from the hillside cave, the train advances cautiously to the gate of the cañon cut out by the river formed by the stream which issues from the perennial spring uniting with another stream which rushes down through a wild and deep barranca behind the small village of Las Canoas. It enters above plunging, boiling waters. Then for eight or nine miles the roadbed has been cut in the rock of the steep mountain side, or has been laid on walls which spring from far below. On such dizzy heights the train hangs and sways and winds through constantly occurring curves. Where mountain buttresses interpose, tunnels open a way, till eight are passed. Within the cañon long vistas of the wildest mountain scenery open before us. The opposite mountain side is precipitous in places, in others cut by gorges. It is everywhere covered with a variety of trees, except here and there on the steeps near the summit, where some Indian has built his hut and cleared a plot for corn or bananas. From our perch, still high on the mountain, we are looking down upon a fertile hacienda, on broad open valleys stretching among low hills, which are covered with heavy tropical forests, on meadows with grazing herds, and on broad fields of corn and cane. In making the descent from the mountain side to Tamasopo siding, the road turns back upon itself in several long loops. At the foot of the mountain it passes through a heavy forest in whose shade is a coffee plantation. The region is in the one of heaviest rainfall. The winds, heavily laden with moisture which arises from the Gulf, are repelled from the heated lowlands, to precipitate on these mountains torrents of rain, as their temperature is lowered by their ascending into cooler regions of air. Yet the temperature of Tamasopo, though a little lower than that of the coast, is still a tropical heat ; and from conditions of so great heat and moisture results a vegetation of great luxuriance. The forests, composed of numerous species, are thick, the undergrowth beneath them is dense, and trees and shrubs are bound together by clambering vines to form an almost impenetrable jungle. Each large tree, with huge spreading branches and leaning trunk, it may be, becomes a garden of plants. On its rough mossy surface root ferns, orchids, bromeliads, and cactuses ; and lifted thus into the air and light they thrive apace. The most abundant tree of these tropical forests is doubtless a fig, *Ficus Segoviae*, with smooth gray bark, and often of vast size, especially when growing

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[2] Garden and Forest **6**: 182, 203. 1893.

side streams. It is upon the fruit of this and other wild figs that pigs, peccaries, and monkeys, largely subsist. The most common oak here is *Quercus Germana*, which bears acorns two inches long. *Dendropanax arboreus*, symmetrical in form, and bearing attractive foliage and fruits, is one of the most interesting trees here; and ***Banara Mexicana*** is pretty when covered with white berries. From Tamasopo to the station at Rascon, where a good restaurant is kept, the road threads valleys and runs between wooded hills and a river bank. The clear blue water shows through gaps of the thickets covering the river banks, and here we first see clumps of a giant bamboo, in each clump five to ten stalks, every stalk four to six inches thick, a gracefully spreading plume twenty to forty feet high. Scattered palm trees soon appear, and as we near Rascon we are running through a forest of palms, straight, slender shafts, thirty feet high, bearing heads of broad leaves. Beyond Rascon, as far as Micos, are more palm forests and bamboos, and rivers and swamps and jungles, alternating with open meadows, which lead back between hills whose sides are covered with oaks. Meadows and glades and mountain tops — all are deer parks; and the Mexican tiger, the puma, prowls through the less frequented wilds of all this region.

On every hand is rich and inviting botanizing ground in an unbroken virgin forest.

Las Canoas is reached from Tampico on the Gulf coast. Tampico is reached by line of steamers from Galveston, New Orleans, New York, and European ports. Leaving Tampico at 6:00 A.M., Rascon (116 miles distant) is reached at 11:20 A.M.; Las Canoas, 144 miles distant from Tampico, at 1:35 P.M.; and Cardenas, where the mountain engines are taken off, at an elevation of 4500 feet, 158 miles distant, at 2:20 P.M. From Rascon to Cardenas (42 miles) an ascent is made of 3500 feet. The Tampico branch of the Mexican Central railroad, passing through San Luis Potosi, makes connection with the main line at Chicalote. The region tributary to this line from Tampico to San Luis Potosi has been visited by Mr. C. G. Pringle, so that American and European herbaria are well supplied with the representative plants of the region.

No more inviting district is within easy access of the American botanist than this one, tributary to the Tampico branch of the Mexican Central railroad. A temporary station could be established here at very little expense and the virgin forest would supply enough botanical material for years to come.— JOHN W. HARSHBERGER, *University of Pennsylvania.*

CURRENT LITERATURE.

BOOK REVIEWS.

Cyanophyceæ and bacteria.

DR. ALFRED FISCHER has made further investigations into the structure of the Cyanophyceæ and bacteria.[1] He admits that Bütschli's central body cannot be explained as contracted cell contents, but insists that there is no such sharp line between central body and "Rindenschicht" as Bütschli figures. The analytical value of staining is thoroughly discussed. The author stained substances of known chemical composition, and came to the conclusion that the coloring does not depend upon a chemical union between the stain and the tissue elements, but is rather a physical phenomenon and does not determine the relationships of albuminoid bodies or the morphological values of cell elements. Fischer claims that Bütschli was mistaken in the assumption that digestion experiments support the theory that the central body is a nucleus. The green rind of the cyanophyceous cell is a genuine chromatophore and can be isolated by reagents. He was not able to demonstrate a layer of protoplasm between the chromatophore and cell wall, but believes that plasmolytic phenomena and the collecting of granules along the cross walls indicate such a layer. The ground mass of the central body is nothing but the principal part of the protoplast which is surrounded by the chromatophore. Very often the ground mass stains only slightly deeper than the chromatophore and cannot be compared with a nuclear network. The ground mass of the central body does not take any part as an independent organ either in cell division or in spore formation. Nor do the granules play any characteristic part during division. In short, there is no nucleus or organ which resembles a nucleus in the Cyanophyceæ, nor is the central body a phylogenetic forerunner of the nucleus of higher forms.

In treating of the sulfur bacteria it is found that, contrary to Bütschli's description, there is no colored rind and colorless central body in Chromatium, but the coloring material is uniformly distributed. Consequently there can be no comparison with the Cyanophyceæ in this respect. Among the sulfur bacteria the central body is found only in individuals which are free from sulfur, and in sulfur-free Chromatium a central body cannot be demonstrated. There are granules in Chromatium and in Beggiatoa which stain red with haematoxylin, but they cannot be called chromatin on such evidence. There are no genuine nuclei in the sulfur bacteria.

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[1] FISCHER, ALFRED.—Untersuchungen über den Bau der Cyanophyceen u. Bakterien. 8vo. pp. —. Jena: G. Fischer. 1897. *M.* 7.

In dealing with the genuine bacteria, the theory that bacteria are nuclei without cytoplasm is regarded as unfounded. After the best fixing agents neither Spirillum nor other bacteria show clear, less deeply staining ends. Bütschli's central body is nothing but the entire protoplast contracted by the plasmolysis of preparation. The contents of the bacterium cell consist of a lining of protoplasm along the wall and a central cavity which in elongated forms is chambered by protoplasmic septa. Present methods fail to demonstrate a nucleus. The more deeply staining granules are not nuclei, or chromatin granules. The relationship of the sulfur bacteria and all other bacteria to the Cyanophyceæ is merely one of loose, superficial morphology. They stand in closer relation to the Flagellatae.

Microtome sections from paraffine material were stained in the most approved manner, and the technique throughout was thoroughly up to date. The plates are exceptionally elegant, aud doubtless show what there is to be seen.—CHAS. J. CHAMBERLAIN.

A laboratory manual.[2]

SUCH is the name given to a little book by Principal Charles H. Clark, of Windsor Hall School. It seems to be the author's idea to furnish a large amount of suggestive material, from which work may be obtained either for elementary or more advanced courses; and he follows, as he states, "the lines suggested in the Report of the Committee of Ten." As the reviewer prepared the botanical part of that report, it was a matter of interest to him, not to say surprise, to see it take this expression. It has never fallen to our lot to be so puzzled by a schoolbook dealing with botany. It is a puzzle both as to its botany and as to its pedagogy. It claims to be adapted for use in elementary courses, but there is no adequate explanation of the terms used or of the structures or functions to which they apply; the terminology is utterly confusing and inconsistent; and there is no morphological thread whatsoever upon which the facts may be strung.

The author seems to have obtained a multitude of facts, but they are as incoherent as a sand bank; and what is worse, the essential structures are most frequently omitted. This is notably true in the treatment of the spermatophytes, where the morphologically important structures of the lower groups are entirely dropped, and the work is confined to the histology of the sporophyte, and a little of its physiology. Such guidance may teach laboratory methods, may collect a mass of unrelated facts without any reference to their importance; but it never can result in a clear conception of plants.

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[2] CLARK, CHARLES H.—A laboratory manual in practical botany. Small 8vo. pp. 271. *figs. 191*. New York, Cincinnati, Chicago: American Book Company. 96 cents.

A good teacher can manage to get along with a lot of poorly digested material, although it is an unnecessary burden, but misrepresentation is unpardonable. We do not have space to quote the many remarkable statements noted in a casual reading of this book, but we must justify our strictures by presenting a few.

The form of the plant (thallophyte) which bears simple spores is known as the *sporophyte* (p. 9).

The male gamete (in spermatophytes) is either the original nucleated protoplasm of the pollen grain, or is one of the nucleated cells formed by the division of that protoplasm in the formation of the male prothallium in a tube which grows out of the pollen grains (p. 11).

Seeds, in the higher plants, result from the fertilization of ovules by pollen grains. Seeds grow directly into ordinary plants when the conditions are favorable. Spores result from cell division. They contain no embryo and do not grow into ordinary plants (p. 36).

In the cells of certain modified leaves of this cluster (in mosses) minute antherozoids are borne (p. 38).

The oospore is raised up above the top of the female plant by a very slender stalk, the seta, and develops there into the sporophyte form of the plant (p. 38).

The enlarged top that develops on the female plant (in mosses) is a sporangium (p. 38).

No sexual reproduction is known to occur in this class (schizophytes). There is consequently no alternation of generations from sporophyte to gametophyte. The plant is the sporophyte (p. 59).

A zygospore is thus produced (in Spirogyra) that becomes encysted and falls to the bottom of the water, where, imbedded in the mud, it preserves the life of the plant until the next season. On the return of spring, the zygospore grows in the asexual way into a new filament. This is gonidial reproduction (p. 98).

Male gametes (in lichens), *spermatia*, conjugate with female gametes, *trichogynæ*, inside the tissues of the hyphæ (p. 145).

A spore fruit results (in liverworts), and the spores develop by fission of cells into small and simple growths called *protonemæ*, from which new plants arise (p. 169).

Mosses are reproduced asexually by different modes of budding, but not, so far as is known, by asexual spores (p. 176).

The capsules (in mosses) containing the egg cells become filled with spores that closely resemble the asexual spores of some other plants (p. 177).

From this fact that their structure is wholly cellular, the plants of the preceding subdivisions are called *cellular cryptogams* (p. 183).

When the spores germinate (in pteridophytes), there is first formed a protonema which develops into a small thalloid leaf called *prothallium* (p. 185).

If the under side of one of these heart-shaped prothallia be examined under the microscope, special differentiations of the cells will be found near the sinus of the heart; these are the *archegonia* or *pistillidia*; they are rounded aggregations of cells.

ith a large centrally situated cell that divides into two. Of these two cells, the lower velops into the egg cell, or oosphere; the upper develops into a tube which becomes ed with a mucilaginous substance that is afterwards discharged, leaving the passage to the oosphere open.

More distant from the sinus of the prothallium are the *antheridia*, situated among e root hairs. In these spirally coiled antherozoids are developed, being finally disrged by the rupture of the cell wall. Accompanying each antherozoid is a small l, the use of which is not understood. Each antherozoid is provided with cilia, by eans of which it swims about when the prothallium is wet. It may in this way pass other prothallia, where, by fertilizing the oosphere, a hybrid variety is produced 185).

Two groups of plants included here are *heterosporous*, *i. e.*, they have two kinds of spores, female macrospores and male microspores (p. 186).

The plant is the sporophyte (the spermatophytes). There are two kinds of res, microspores or pollen grains, and macrospores borne in embryo sacs (p. 205).

The feature that especially distinguishes the spermaphytes from the plants of e seven preceding subdivisions is the production of true seeds, which are the result the fertilization of the embryo cell by the receipt of the contents of the pollen cell. The embryo cell is borne in a pistil (p. 206).

The ovules are borne in closed cavities, the *ovaries*, at the base of *pistils*, which e modified leaves; the pollen cells are borne in anthers raised on stamens; which are also modified leaves (p. 218).

The contents of the pollen grain now mingle with those of the embryo sac, and the life of the seed commences (p. 219).

Some plants develop their leaves alternately; others develop them in pairs. From se facts have arisen a division of the angiosperms (into monocotyls and dicotyls) 220).

The above quotations need no comment, and could some of the illustrans be reproduced the same remark would be appropriate, although some ell-known and classic illustrations help the general average.—J. M. C.

Essays on plant life.

Popular books about plants are few. Accurate and interesting books out plants are rare indeed. We justly welcome, therefore, a book, embodyg these qualities, which has lately been issued by Dr. J. C. Arthur of Pure University and Dr. D. T. McDougal of the University of Minnesota.[3] consists of twelve essays, selected in equal numbers by the two authors m popular addresses and articles presented within the last few years. ese have been more or less modified to adapt them to each other and to rrent botanical knowledge. It will not be amiss to quote the titles of the says to indicate in a measure the compass of the book.

[3] Arthur, J. C., and MacDougal, D. T.—Living plants and their properties; llection of essays. Small 8vo., pp. x + 234. *figs. 28.* New York; Baker & Taylor. neapolis: Morris & Wilson. 1898.

The six by Dr. Arthur are: The special senses of plants; Wild lettuce as weed and compass plant; Universality of consciousness and pain; Two opposing factors of increase; The right to live; Distinction between plants and animals.

The six by Dr. McDougal are: The development of irritability; Mimosa, a typical sensitive plant; How cold affects plants; Chlorophyll and growth; Leaves in spring, summer, and autumn; The significance of color.

Into a detailed examination of the essays we cannot go. All are well written and interesting. Dr. McDougal's deal chiefly with important facts of plant activity, while Dr. Arthur's are inclined to be more speculative and philosophical. The latter, therefore, offer the greatest opportunity for criticism. Few will be able to concede the correctness of the author's definitions and premises in the essay on the Universality of consciousness and pain, wherein he seeks to maintain the thesis that "all living organisms, whether animal or plant, are capable of conscious pain to a degree commensurate with the requirements of their nature." Indeed, he seems to destroy his own argument by concessions. For at the outset he excludes from consciousness, as he uses it, all idea of self-consciousness, which, he adds, "is necessary that the individual may, for instance, be aware of its own identity" (p. 65). Later he says: ". . . when the organism is aware of a feeling of pleasure or pain, or of any other sensation, *knowing that the same is located within its own organs*, it is possessed of consciousness" (p. 71).

Nor can we believe that Dr. Arthur has really found in the "carbohydrous investment" of plants, and the "nitrogenous investment" of animals, a "crucial test" for distinguishing them. Who can accept a criterion which, the author says, excludes the Olpidiaceæ and the Synchytriaceæ from the rest of the Chytridineæ? Does not the argument "it is known with much certainty that they have no cellulose envelope; they are, therefore, not plants, and must, in consequence, be animals," beg the whole question?

It is a pity that the book should be so poorly manufactured. Bad proof-reading and a "countrified" binding, spoiling the artistic cover design, show the novice hand of the Minneapolis firm which did the mechanical part. The work of the authors deserves a better setting. The book may well find a place in public and school libraries, and is commended for popular reading. C. R. B.

The phytogeography of Nebraska.[4]

THIS is a distinct and noteworthy addition to the ecological plant geography of this country. It is a general survey, the first of a series of installments dealing with the floral covering of Nebraska from the phytogeographic standpoint. The authors follow very largely the methods of Drude, especially as outlined in his *Pflanzengeographie von Deutschland.*

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[4] POUND, ROSCOE and CLEMENTS, FREDERIC E. — The phytogeography of Nebraska. I. General Survey. 8vo., pp. xxi + 330. Lincoln, Nebraska: Jacob North & Co. 1898.

The introduction discusses the relation between phytogeography and biology, and gives an interesting history of the investigation of the Nebraska flora. The first chapter is introductory, dealing with the physiognomy and climatology of the state. The second chapter is entitled "Statistic and regional limitation," and after the enunciation of certain general principles there is to be found a characterization of the four regions into which the authors subdivide the state: the wooded bluff and meadow land, prairie, sand-hill and foothill regions. Then follow lists of species in which these regions agree and differ. The third chapter, the "Vegetation forms of the flora," is of great interest. The authors at this point depart somewhat from Drude's classification, but such departure seems almost inevitable in view of the great difference between the life conditions in Germany and Nebraska. The main subdivisions are into woody plants, half-shrubs, pleiocyclic herbs, hapaxanthous herbs, water plants, hysterophytes, thallophytes. These groups are quite intimately subdivided, especially the pleiocyclic herbs and thallophytes. The next chapter has to do with the "Ecological and biological relations of the natural groups." The pteridophytes and spermatophytes are discussed in successive groups with regard to habitat, or as Warming would say, they are referred to their respective plant societies. The fifth and last chapter treats of the "Plant formations of the state." These are quite fully treated and are, of course, full of interest to plant geographers. Perhaps the most distinctive formations are those of the sand hills, with their bunch grasses, blow outs, and sand draws; and of the foothills, with their undershrubs, mats, and rosettes.

Inasmuch as this is the pioneer work of its kind in America, the task of its authors was peculiarly difficult. Questions of terminology in ecological plant geography are of no easy settlement because the field is so very new, and the transference of German classifications and technical terms to American soil involves great difficulty, just as the correlation of European and American geological strata caused confusion when the attempt was first made. The adverse criticisms suggested by a hasty perusal have to do largely with terminology, and hence are not of the most vital importance. There seems to be, for example, a strong tendency to use Greek derivatives in place of the simpler and more expressive English equivalents. The extension of the term "thallophyte" to include mosses and liverworts seems very objectionable, not only because the term has been long preempted by morphologists, but because there is a radical ecological distinction between the true thallus and the moss gametophyte. The rejection of Warming's term mesophyte is very questionable, since it involves the introduction of several new terms and destroys the unity of the classification; a subdivision of the mesophytes into forest, grass, and waste societies would serve the authors' purpose fully as well.

It may be too early as yet to predict whether the direction to future work in plant geography will be given by Warming or by Drude; and so whether we shall speak of ecology or phytogeography, of life forms or of vegetation forms, of plant societies or formations, is yet to be decided. Perhaps the solution will be by a division of labor, phytogeography including the larger problems of distribution and dealing with extensive formations, while ecology will have to do more with local and habitat relations, including anatomical as well as field investigation. In any event, the *Phytogeography of Nebraska* will be an indispensable work to all American students along either line.— HENRY C. COWLES.

MINOR NOTICES.

IT IS A PLEASURE to record the publication of an English translation of the admirable *Lehrbuch der Botanik*[5] by Strasburger, Noll, Schenck and Schimper, of the University of Bonn. This translation has been made by Dr H. C. Porter, of the University of Pennsylvania, from the second German edition, which was noticed in this journal in August 1896. The publication has been long delayed (it was announced for last March), but this delay has doubtless been unavoidable, and it has certainly whetted desire. The translator has succeeded better than was to be expected in preserving the flavor of the original and at the same time putting it into idiomatic English. He has avoided introducing new terms, in rendering technical German ones, by adhering to the usage of previous translators. There may be some question of the wisdom of too slavish conformity, but it is at least an error on the side of safety. We are pleased also to announce that the publishers have decided to issue the book in two parts, the first containing the morphology and physiology, and the second the special morphology of cryptogams and phanerogams. When we add that the manufacture of the book leaves nothing to be desired (the imperfections of the color printing being entirely unimportant, as the figures themselves are) there is nothing more to be said. C. R. B.

GARDEN-MAKING is attractive to many more people than know how to go at it, and garden-making would be undertaken by many more people if they had a proper mental picture of what a garden should be and knew how to go about realizing it. The last volume of the *Garden-craft series*, by Professor L. H. Bailey,[6] endeavors first to create the proper conception and then show how the picture can be painted in plants and soil.

[5] STRASBURGER, NOLL, SCHENCK and SCHIMPER.— A text-book of botany, translated from the German by H. C. Porter. 8vo. pp, x + 632. *figs. 594*. London & New York: The Macmillan Co. 1898. $4.50. In two volumes, each $2.50.

"This book understands the garden to be that part of the premises which is devoted to ornament, and to the growing of vegetables and fruits either for the home consumption or for market. The garden is, therefore, an ill-defined demesne; but the reader must not make the mistake of defining it by dimensions, for one may have a garden in a flower pot or on a thousand acres. In other words, this book believes that every bit of land which is not used for buildings, walks, drives, and fences, should be planted. What we shall plant—whether sward, lilacs, thistles, cabbages, pears, chrysanthemums, or potatoes—we shall talk about as we proceed."

And talk about it the author does, in the most interesting and attractive way, bringing forth out of the treasures of his experience and observation things new and old. In a hundred pages and more of general advice he tells the things which the novice most needs to know, and, if we mistake not, many things which the professional gardener would be profited by knowing. Then follows a discussion of the principles of landscape art as they apply to planting city yards, suburban grounds or rural estates. A third section is devoted to suggestions in regard to ornamental planting; a fourth to the fruit plantation, and another to the vegetable garden. In fact there is no one who owns the land on which he lives who would not find in this book something of profit and interest.—C. R. B.

The annual report of Mr. Fawcett as director of the gardens of Jamaica contains many items of interest in connection with his recent description of gardens in this journal (Nov. 1897). During the year 264,000 plants were distributed from the Hope Gardens to planters and farmers, and to this total is to be added the specimens sent out from the other gardens, which are used as minor distributing centers. Cultural and acclimatization experiments of great value have been carried on, and the economic efficiency of the system of gardens is certainly many times in excess of the actual cost to the island government. Among the points of scientific interest presented in the report, it is noted that Bermuda lilies grown in Jamaica show a rapid multiplication of bulbs, with no resting period of any sort.

Although no systematic survey is in progress, seven new species of phanerogams and forty-four species of mosses were collected during the year by various members of the staff.—D. T. McDougal.

NOTES FOR STUDENTS.

Messrs. Hitchcock and Clothier have made a report upon the vegetative propagation of the perennial weeds of Kansas.[7] In it is contained an

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[6] Bailey, L. H.—Garden-making: suggestions for the utilizing of home grounds. Edited by L. R. Taft, F. A. Waugh, and Ernest Walker. 12mo., pp. viii + 417, *figs.* New York: The Macmillan Co., 1898. $1.

[7] Bull. 76, Feb. 1898, Experiment Station of the Kansas State Agricultural College.

exhaustive list of the common weeds, grouping them as follows: those which propagate by creeping roots, by creeping stems, or by forming "crowns." A summary is made of a number of experiments upon weeds with exceptional powers of vegetative reproduction. One of the most striking results was in the case of *Enslenia alba*, the climbing milkweed. Ten one-inch pieces of the root stock were planted ten inches below the surface, and seven of these sprouted. The immediately practical value of the report is found in the methods suggested for killing perennial weeds, and in illustrated descriptions of the underground parts of forty-eight of the commonest vegetable pests.—J. G. COULTER.

DR. DOUGLAS H. CAMPBELL,[8] in continuing his studies among the lower monocotyledons, has investigated the peculiar and monotypic *Lilæa subulata*, a characteristic Pacific coast form, ranging from Oregon to southern South America. In some important respects the results confirm those already obtained by the author in his investigation of Naias and Zannichellia, such as the cauline origin of both microsporangia and megasporangia, and the plerome origin of the sporogenous tissue of the stamen. This departure from the ordinary hypodermal origin of this tissue is noteworthy. The usual indefiniteness of the tapetum was also observed, one or two layers of wall cells and certain sterile sporogenous cells functioning as such. Just what the "tapetum proper" is it would be difficult to say.

The development of the megaspore presented no unusual characters, but the meager preparations did not permit a clear statement. There is enough variation in these structures to demand multiplied preparations before conclusions can be regarded as safe. The antipodal cells are not of the evanescent type, but organize into vigorous cells. A remarkable exceptional condition was the occurrence of a mass of tissue in the micropylar end of the embryo sac, replacing the egg-apparatus. Just what this signifies it is hard to say. Of course, we should be pleased to discover some certain evidence of the occurrence of nutritive tissue in the embryo sac of angiosperms before fertilization, and especially in the micropylar region, and every such observation as the above stimulates our expectation.

Perhaps the most unexpected result is the peculiar relation of the primary root apex to the axis of the embryo. Instead of lying in the axis of the terminal cotyledon towards the suspensor, it is directed to one side, almost continuing the axis of the lateral stem apex. The author regards this as a lateral origin of the root, and remarks that it is suggestive of the root of Isoetes, the basal segments of the embryo and the suspensor being possibly the equivalents of the "foot" of pteridophytes.

The author again finds that the primary suspensor cell does not divide, and that the embryo is derived entirely from the terminal cell resulting from the first division. This is certainly different from most dicotyledons studied, and does not hold for Lilium, but it may be quite a constant feature among the more primitive monocotyledons.

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[8] Annals of Botany **12**: 1–28. 1898.

It is a satisfaction to note that these investigations are confirming the growing belief that many of the so-called "reduced" forms are rather primitive forms.—J. M. C.

BY ISOLATING another form from the river Thames, Professor H. Marshall Ward[9] has made an addition to our list of violet-pigment bacteria. The form is somewhat polymorphic. When in favorable culture media, the bacterium may appear in the form of a filament 50–60μ in length, though it is usually a bacillus. When in adverse cultural environment it may be reduced to the micrococcus type. It is motile, being very actively so in the case of the bacilli of medium length. No spores are formed, unless the micrococcus forms be considered such, and they do not show the characters of true spores. The bacterium is not pathogenic for guinea pigs.

In all ordinary culture media the bacillus develops abundant growths. In gelatin plates the contour of the colonies is very similar to that of *Bacillus typhosus*, but as they become older those near the surface break through as small cones in a way very different from the typhoid colonies.

At about ten days' growth liquefaction begins, and at this time the superficial colonies begin to show a slight formation of the violet pigment which darkens slowly, and after several days becomes as dark in color "as a strong solution of gentian violet." By means of several culture media it was shown that the pigment is in the living zooglea mass, and not mixed with the active bacilli beneath the mass. Microscopical examination failed to demonstrate the existence of the pigment within the bacterial cells, but indicates that it exists external to the cell-walls which compose the zooglea matrix. The pigment is slightly soluble in water and readily so in alcohol.

There have been at least a dozen other descriptions of violet-pigment bacteria, and the opinion has prevailed among bacteriologists that when the life-histories are carefully worked out, several or perhaps all of the forms described may be reduced to a single type. The bacillus here described, however, seems to have characters which make it distinctly different from those previously described.— OTIS W. CALDWELL.

ITEMS OF TAXONOMIC interest are as follows: A. A. Eaton[10] has described a new Isoetes (*I. minima*) from Washington, being trilobed and with partial velum, as well as the smallest American species. W. N. Suksdorf[11] has published a key to the species of Plectritis and Aligera, the former with nine

[9] Annals of Botany **12**: 59. 1898.

[10] Fern Bulletin **6**: 30. 1898.

[11] Erythea **6**: 21–24. 1898.

species, the latter with ten, one of which is new. George V. Nash[12] has published a new genus of grasses, *Blepharoneuron*, a monotypic genus based upon *Vilfa tricholepis* Torr. G. N. Best[13] has described a new genus of mosses, *Fabroleskea*, based upon *Leskea Austini* Sulliv. Edward L. Greene[14] has described several new species of Compositæ from a collection made by E. O. Wooton in southeastern New Mexico, among which is a new genus, *Wootonia*, "about equally allied to Bidens and Cosmos." L. M. Underwood[15] has published a discussion of *Selaginella rupestris* and its allies, in the course of which he describes six new species. John K. Small,[16] in continuing his descriptions of numerous new species from the southern United States, proposes a new genus of Paronychiaceæ, *Forcipella*, based upon *Siphonychia Rugelii* Chapm. E. O. Wooton[17] has described an interesting new rose from New Mexico, *R. stellata*, which is the second member of a hitherto monotypic section (MINUTIFOLIÆ) of the genus. Edward L. Greene,[18] in recent folios of *Pittonia*, has published as follows: Results of a study of the Macoun Canadian collection of the species of Antennaria, fifteen new species being described, to which are appended three other new species of the genus from the southwest; a new genus of the Senecionidæ, *Rainiera*, based upon *Prenanthes stricta* Greene (*Luina Piperi* Robinson, *Psacalium strictum* Greene); seven new species of Erigeron; the establishment of the genus *Microsteris*, based upon *Collomia gracilis* Dougl., from which six additional species are segregated; and the establishment of the genus *Gymnosteris*, based upon *Collomia nudicaulis* Hook. & Arn.— J. M. C.

Edward L. Greene[19] calls attention to the occurrence of "parthenogenesis" in *Antennaria plantaginifolia*, as well as in some of the so-called cleistogamous flowers of Viola. Of course he only means the setting of seed without pollination, but the observation suggests a profitable subject of investigation for the morphologist. It is hardly likely that it is a case of parthenogenesis, for this has been disproved for all such claims for the higher plants, but it is always interesting to know the origin of the vegetatively developed embryos.— J. M. C.

Considerable information about the natural conditions of plant life and the extent of the vegetation in Alaska is embodied in a recent report to

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[12] Bull. Torr. Bot. Club **25**: 88. 1898.

[13] Bull. Torr. Bot. Club **25**: 108. 1898.

[14] Bull. Torr. Bot. Club **25**: 117–124. *pl. 330–335*. 1898.

[15] Bull. Torr. Bot. Club **25**: 125–133. 1898.

[16] Bull. Torr. Bot. Club **25**: 134–151. 1898.

[17] Bull. Torr. Bot. Club **25**: 152–154. 1898.

[18] Pittonia **3**: 273–311. 1898.

[19] The Plant World **1**: 102. 1898.

Congress[20] regarding the desirability of establishing experiment stations in that region. In many places the soil is remarkably rich, and native grasses and associated plants attain uncommon stature. A list is given of over one hundred species of economic plants collected by Mr. Evans.—J. C. A.

A RECENT PAPER by W. West and G. S. West[21] presents many interesting facts concerning the habits, methods of reproduction and structure of the Conjugatae, together with an interesting diagram of possible phylogeny.

One is not apt to realize the extent of parthenogenesis and other means of non-sexual propagation that are present in this group of plants. Filaments may fragment, and resting cells or cysts may carry the species through unfavorable conditions, but the most interesting structures are the parthenogenetic spores called aplanospores. These are thick-walled reproductive cells, formed by the contraction of the protoplasm in a vegetative cell and the secretion around itself of a heavy membrane. That such structures are parthenogenetic spores is proved by their not infrequent occurrence side by side with zygospores in the same material. They have been observed in several species of Mougeotia, Zygnema, and Spirogyra, as well as among the desmids in Closterium, Spondylosium and Hyalotheca. There is, however, one genus, Gonatonema, that reproduces entirely through such non-sexual spores, and yet is so closely allied to Mougeotia that the filaments are not to be distinguished in the sterile condition. There can be no doubt of the close affinities between these two genera, although one has entirely given up the method of sexual reproduction.

The diagram of phylogeny places Mougeotia at the end of a long line of ascent, with Gonatonema as a degenerate offshoot, and Temnogametum as a side branch. Spirogyra and Zygnema with other allied genera occupy the tips of another distinct system of branches. The Desmidiaceæ are regarded as an offshoot and somewhat degenerate group from this second main branch, and are not connected directly with the unknown ancestral types.—BRADLEY MOORE DAVIS.

ARTHUR H. CHURCH[22] has investigated the polymorphy of *Cutleria multifida* (Grev.). This plant unfortunately is not found on our temperate coast, so that its interesting peculiarities cannot be very well known to American botanists. There are two plants, described as the genera Cutleria and Aglaozonia, that have long been suspected to be phases of a complicated life cycle, and this paper largely deals with this problem.

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[20] TRUE, A. C.—A report to Congress on agriculture in Alaska, including reports by Walter H. Evans, Benton Killin, and Sheldon Jackson. Bulletin of Office of Exper. Stations, no. 48, pp. 36, *pl. 23*. 1898.

[21] Annals of Botany **12**: 29–58. *pls. 4* and *5*. 1898.

[22] Annals of Botany **12**: 75–109. *pls, 7–9*. 1898.

Cutleria is a delicate little plant of the Phæozoosporeæ, that commonly grows in quiet water at a depth of at least two fathoms below tide mark, and vegetates at a mean temperature of 16°. It is widely distributed along the coast of Europe and in the Mediterranean, but is a seasonal form, being quite sensitive to changes of temperature. Thus at Plymouth, England, it is a summer annual which disappears in October. Cutleria bears sexual organs that discharge biciliated gametes of two sizes which have been observed to conjugate, the smaller with the larger. But the sexuality apparently depends upon a narrow range of physical conditions, and when these conditions are not present the plant is parthenogenetic. Thus, although the process of fertilization has been observed at Naples by two investigators, Reinke and Falkenberg, parthenogenesis is known to be extensively present among these plants in the English Channel at the end of the summer. Perhaps the parthenogenesis is associated with a fall in temperature. Extensive experiments by various observers have proved that the oospheres of Cutleria, whether fertilized or developing parthenogenetically, produce young plants with undoubted Aglaozonia characters.

Aglaozonia is a perennial on the English coast, much coarser in histology and stronger constitutionally than Cutleria, for it can stand a range of temperature from less than 3° to more than 20°. It also grows in far more exposed situations than the latter plant. Church has been able to raise young plants from the zoospores of Aglaozonia, and these developed protonema-like creeping filaments that finally matured Cutleria antheridia. These may be regarded as "precociously developed" male plants. Thus experiment has connected back and forth into one life history the forms formerly known as Cutleria and Aglaozonia.

It is well to bear in mind how unsettled are the data in respect to sexuality among the Phæozoosporeæ at the present time. *Ectocarpus siliculosus* is one of the classical forms in which sexuality among these algæ was first announced. But Kuckuck believes that this species is constantly parthenogenetic at Kiel, and Reinhart has observed both the conjugation and direct germination of gametes. And again, extensive studies by Sauvageau upon several species of Ectocarpus indicate that motile cells usually considered as gametes germinate without difficulty.—BRADLEY MOORE DAVIS.

NEWS.

M. J. Istvanffy has been appointed Professor of Botany at the University of Koloszvar.

Professor E. Zacharias has been appointed director of the botanical garden at Hamburg.

Dr. Eduard Strasburger has been elected a foreign member of the National Academy of Sciences.

M. O. Mattirolo, of Bologne, has been appointed Professor of Botany and Director of the botanical gardens at Florence.

Dr. R. A. Harper, of Lake Forest University, has been appointed Professor of Botany at the University of Wisconsin, to succeed Dr. Charles R. Barnes.

Dr. Thomas W. Kirk, late chief conservator of the forests in New Zealand, and long a most indefatigable investigator of the flora of that island, is dead.

A rich merchant of Stockholm, M. F. Kempe, has given to the university about $40,000 to found a chair of "biological botany," to be occupied by Dr. A. Lundström.

Professor D. W. Penhallow has published as a reprint from the *Trans. Roy. Soc. Can.* an interesting "Review of Canadian Botany," extending from 1800 to 1895. The bibliography contains 470 titles.

Dr. Gintl, of Prag, Bohemia, intends establishing a botanical exchange bureau in the autumn. Lichens, Hepaticæ, Musci, and Pteridophyta of Europe, and Spermatophyta of central Europe, will be offered.

Dr. A. J. Ewart, 33 Berkeley st., Liverpool, England, who has undertaken to translate Pfeffer's *Physiologie* into English, desires authors to send him a copy of their works that the literature may be cited to date.

M. Eugène Autran has published (*Bull Herb. Boiss.* 6 : 81–84. 1898) an interesting sketch of the botanical career of Nicolas Alboff, who at the time of his recent death was botanist for the Museum de la Plata, Argentine Republic. Alboff was practically the only botanist who had a personal acquaintance with the trans-Caucasian region of his native country, while his *Prodromus florae Colchicae* was the fruit of extended travel and collection in Central Asia. He went from the Boissier Herbarium to South America in 1895, bound then upon a year of botanical exploration of Tierra del Fuego.

PROFESSOR W. W. BAILEY has succeeded in raising among his friends the sum of $1029 for the use of his department, with much more promised. The money was accompanied by messages appreciative of his long and faithful service.

DR. FRITZ NOLL, of the University of Bonn, on April 1 was appointed *etats-mässigen Professor* of Botany at the Royal Academy of Agriculture at Popplesdorf, to succeed Professor Dr. F. Körnicke, who has been nominated as privy councillor and retires from active service, but retains the direction of the economic section of the garden of the Academy. Dr. Noll retains his position in the University of Bonn.

THE COMING MEETING of the A. A. A. S. at Boston promises to be one of the most notable in the history of the association. It is the fiftieth anniversary, and special efforts are being made to arrange a worthy celebration. The local committees have been appointed, and the week selected is August 22 to 27. The local secretary is Professor H. W. Tyler, of the Massachusetts Institute of Technology. The usual number of affiliated societies will meet at the same time, among them the Botanical Society of America. The meetings will be held in the rooms of the Massachusetts Institute of Technology and of the Boston Society of Natural History, in three closely adjoining buildings.

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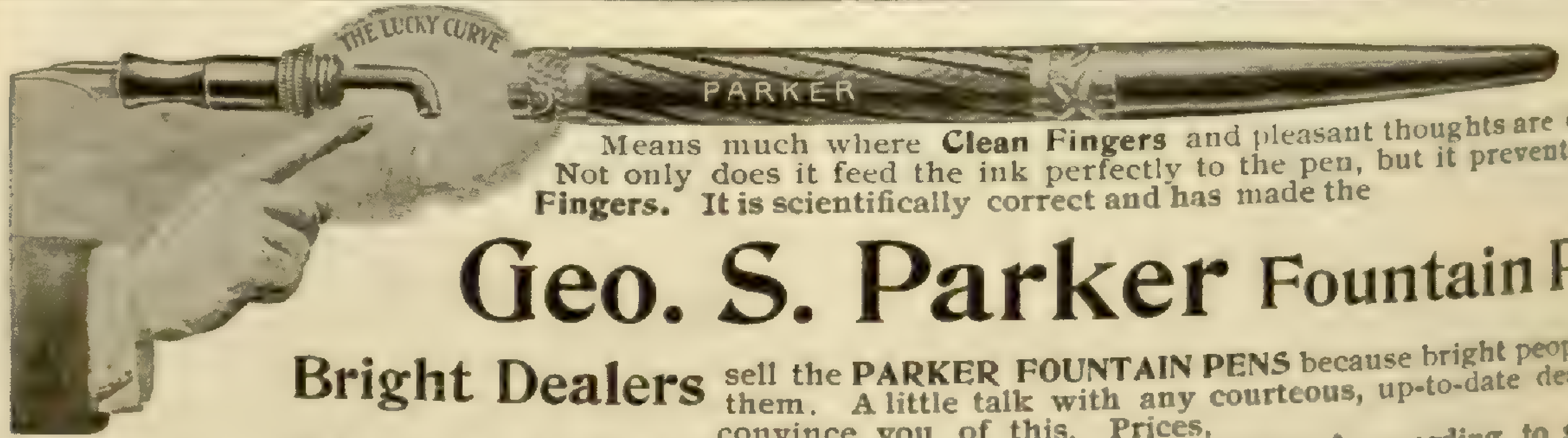

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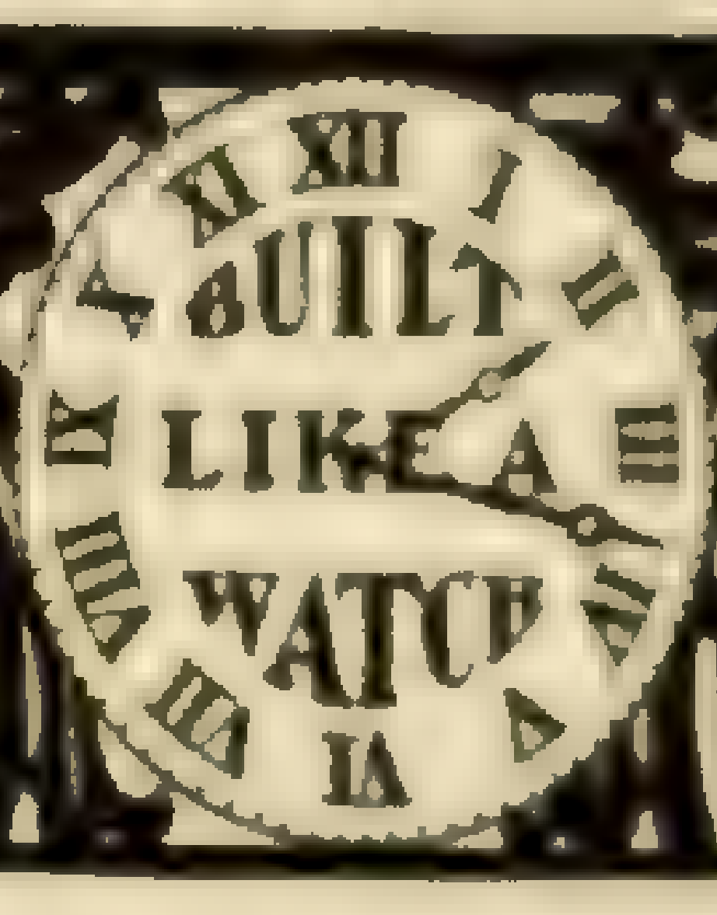

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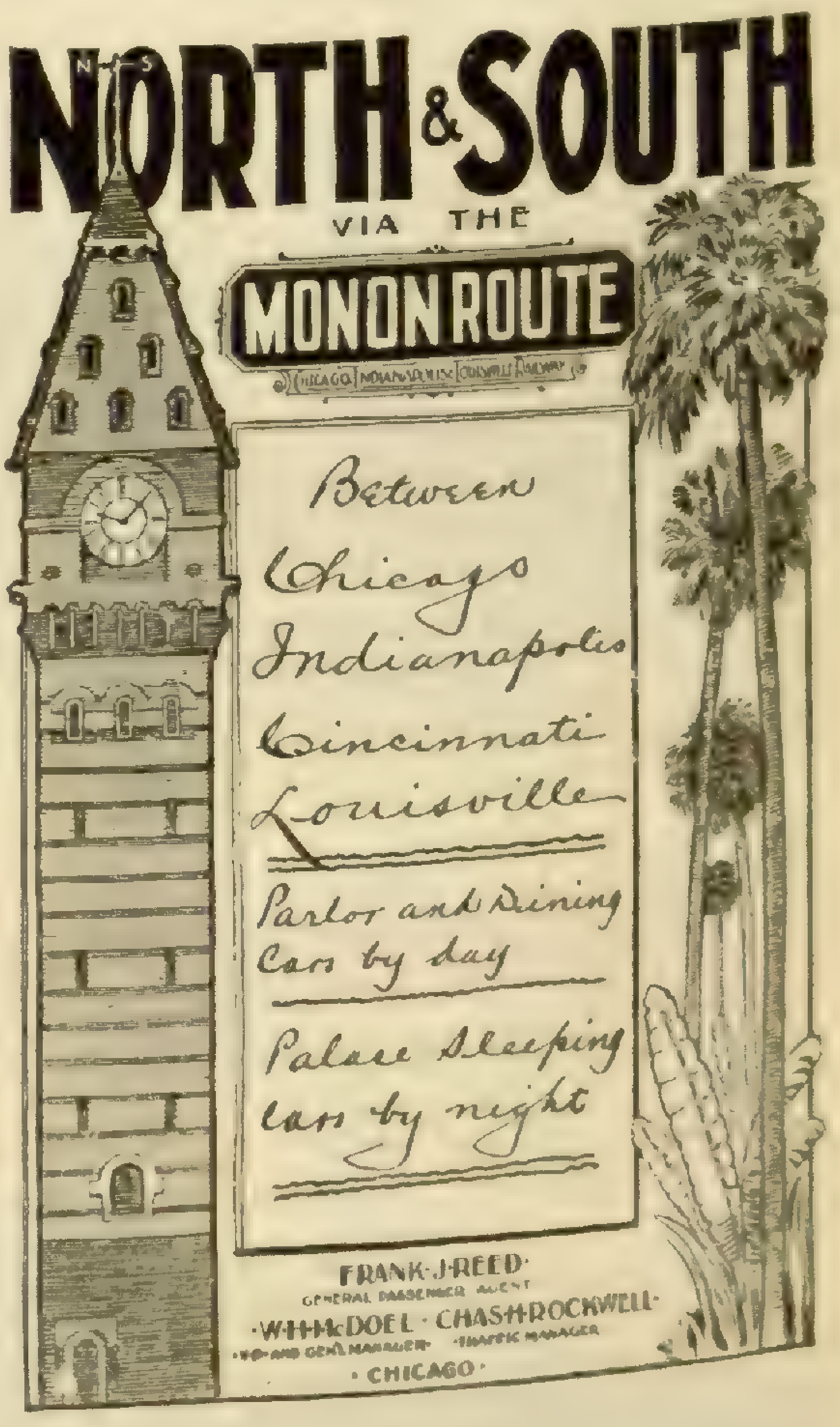
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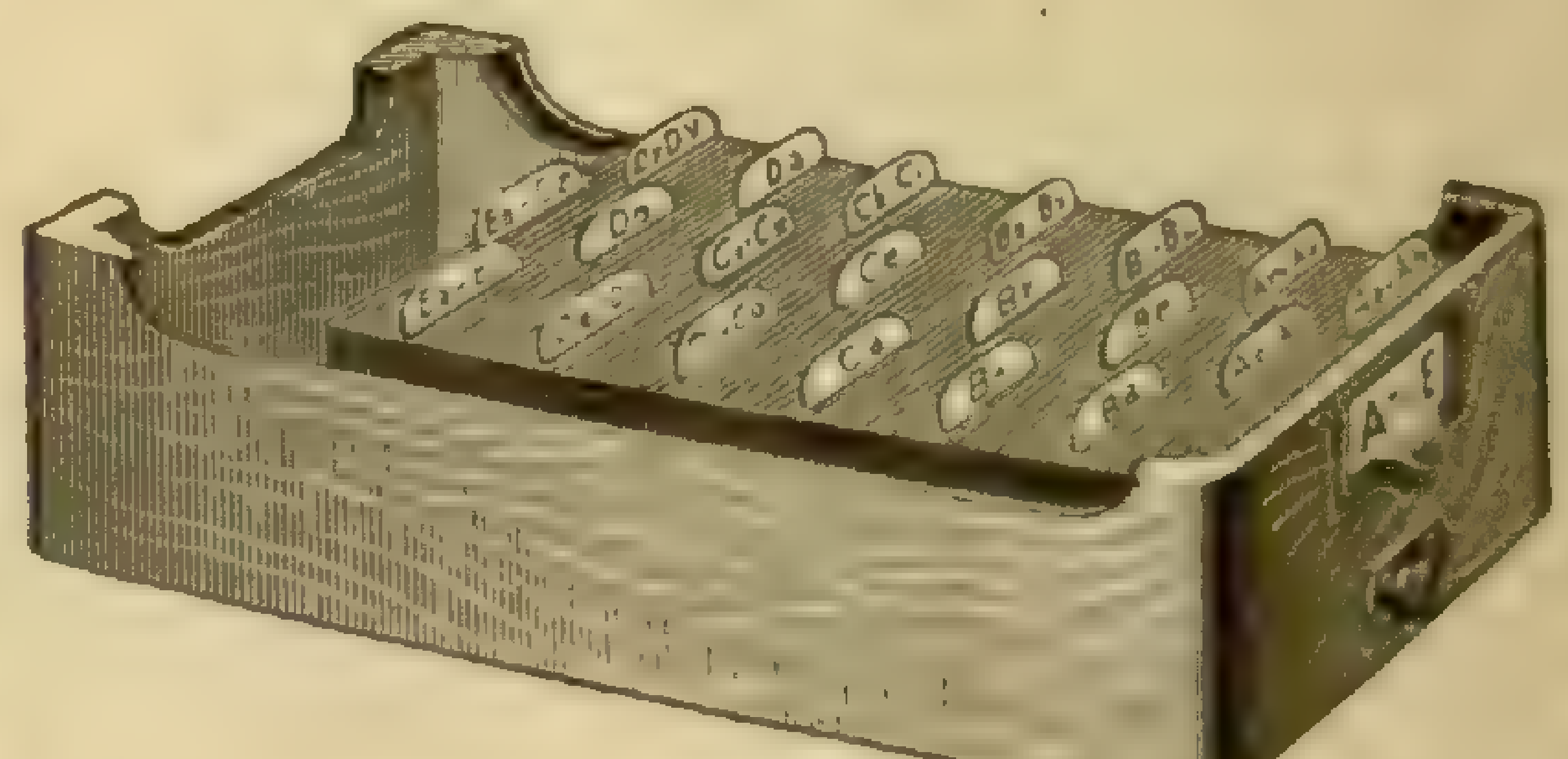

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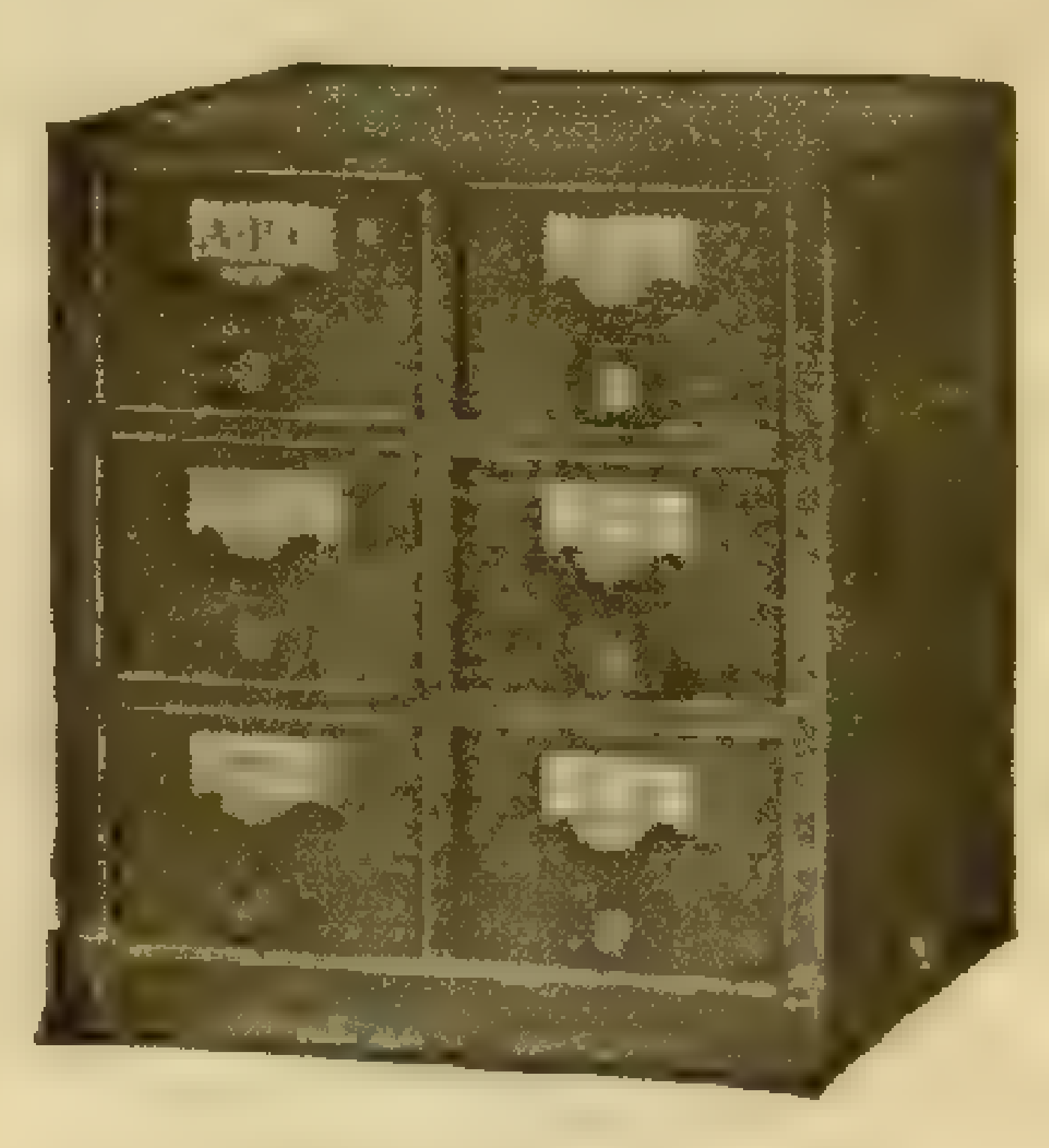

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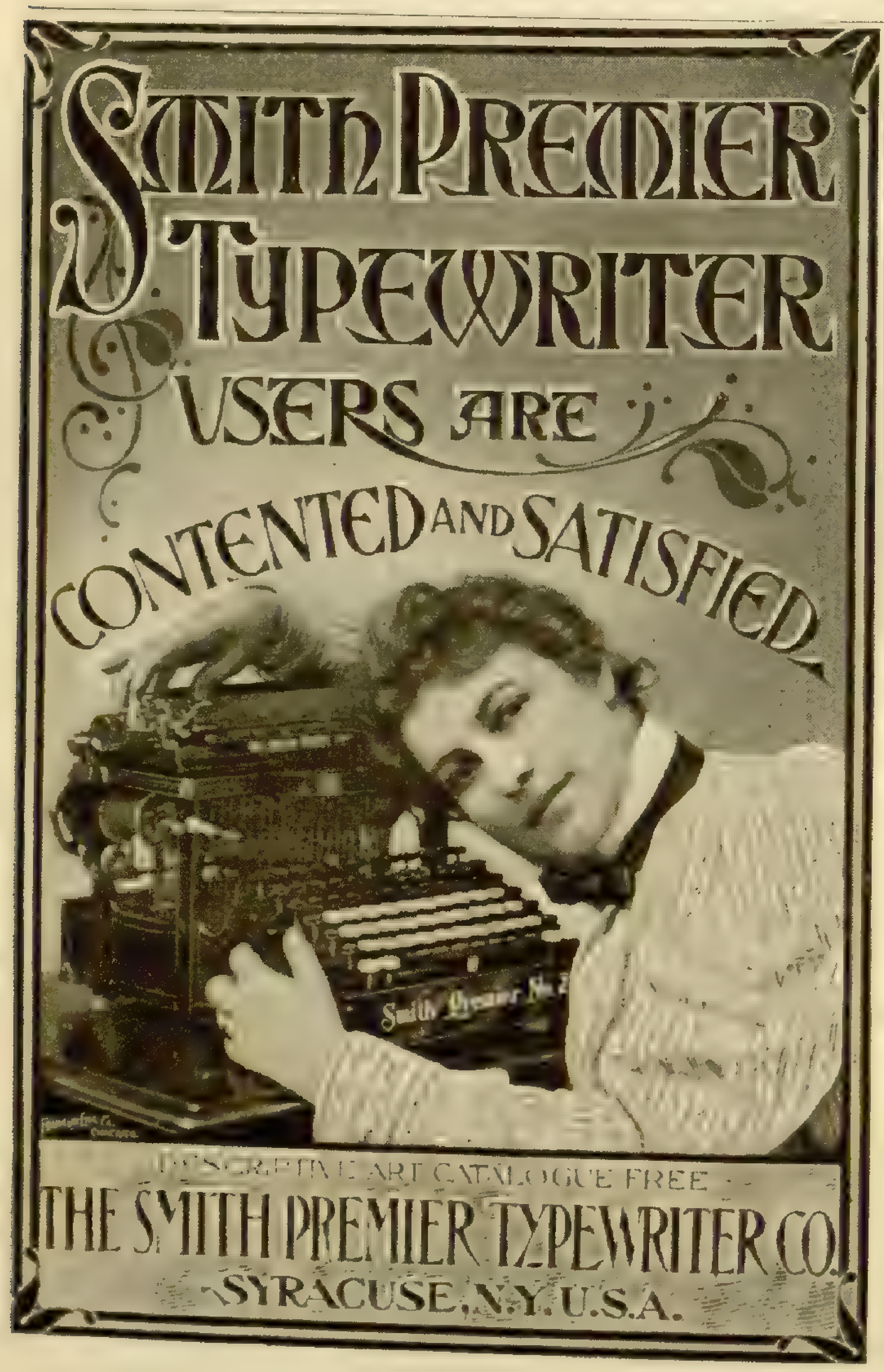

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VOLUME XXV NUMBER 6

BOTANICAL GAZETTE

JUNE 1898

THE VEGETATION REGIONS OF THE PRAIRIE PROVINCE.

ROSCOE POUND and FREDERIC E. CLEMENTS.

(WITH PLATE XXI)

THE vegetative covering of the North American continent falls naturally into two great areas, forest and plain. At first thought it would seem that these were primary phytogeographical divisions, but a comparison with the vegetative covering of other continents proves the contrary. Considered as a phytogeographical feature, the North American forested area is an entity; from a floristic or formational standpoint, it may be analyzed into several distinct portions of widely separated relationship. The ground-tone of the great bulk of the North American forests is that of the forests of British North America, which are closely related to those of middle-north Europe and Siberia, constituting with them the northern realm of Drude and the sub-arctic region of Engler. Three great belts extend southward from this northern mass, each undergoing profound changes in type, and becoming differentiated into well-characterized regions. The floristic separation of these regions from the northern forest-region is so great that the relationship is always much less close than that existing between the floral covering of British America and that of northern Eurasia, and in one or two cases it practically disappears. The forests of Mexico and Central America are tropical, or subtropical, and are both floristically and formationally distinct from the northern forests. So different are certain portions of the plains with respect to vegetative covering that they may be regarded as scarcely more than topographically similar. If North America were to be considered alone, a primary division of the vegetative covering into forest and plain would be useful in certain respects. But these areas are merely the North American representatives of certain zones or realms among those into which the vegetation of the entire earth is divided. In consequence they are not to be distinguished as phytogeographical divisions at all, but as aggregates of divisions, which are characterized by a common type of vegetation-form, or by a group of such types.

Grisebach, having in mind apparently only the gross features of the continental floral covering, distinguished but four divisions, forest domain, prairie domain, Californian littoral domain, and Mexican domain. In the prairie domain he includes not only the prairies proper and the great plains, but the great basin, and the high plateaux of Arizona and New Mexico as well, styling them eastern, northern, and southern prairies respectively. Grisebach practically disregards the true, or eastern prairies, characterizing only the northern and southern ones, which are by no means prairies in a phytogeographical sense, and scarcely more in a physiographical one. As a result of more careful analytical study of the floristic features of the continent, Engler has separated the floral covering into seven provinces: (1) North American lake province, (2) Appalachian province, (3) Prairie province, (4) Californian coast province, (5) Oregon province, (6) Rocky mountain province, (7) Colorado province, the last comprising the vast unforested region between the Rocky mountains and the Sierra Nevada. In 1887, in the *Atlas der Pflanzenverbreitung*, disregarding division into provinces, Drude outlines a number of vegetation regions upon the floral map of North America, which correspond to the regions proposed in his *Handbuch der Pflanzengeographie*. These are fourteen in number: (1) Glacial forest and thicket region of Alaska, (2) Canadian forest region, (3) forest region of the North

American lake country, (4) Columbian littoral forest region, 5) forest and alpine region of the northern Rocky mountains, 6) northern forest-prairie region, (7) Missouri prairie region, 8) steppe and salt-waste region of the Rocky mountains, (9) Californian lowland, subalpine and alpine region, (10) deciduous forest region of the Mississippi basin, (11) evergreen region of the South Atlantic states, (12) steppe and desert region of Arizona, (13) chaparral region of Texas and northern Mexico, 14) North Mexican subalpine and alpine region. Many of these regions are well defined, while others manifest too great reliance upon inaccurate data. This is especially evident in the case of the Missouri prairie region, which is erroneous both as to boundary and as to characterization. Drude makes the eastern boundary of this region follow the west bank of the Mississippi to the confluence of the Ohio, where it bends to the east to include the greater portion of Illinois, then turns westward along the southern border of Wisconsin to the Minnesota valley, whence, passing into the northern forest-prairie region, it runs northwest to Beaver river in Saskatchewan, and then southwest to the head waters of the Saskatchewan in the foothills of the Rocky mountains. Taking the western border of the 20 per cent. wooded area as the line of demarcation between the forests of the Alleghany province and the prairie province, the eastern third of Texas, most of the Indian territory, nearly the whole of Missouri, and the southern portion of Iowa, belong to the forested province. Even if a much higher per cent. of woodland be thought necessary to characterize an area as forested, the dense woods of Louisiana, Arkansas and Missouri are indubitable evidence that these states are an integral part of the Alleghany province. To the north of the prairies of the Missouri, Drude distinguishes the prairies and plains of Manitoba, Saskatchewan, Alberta, and Athabasca as the northern forest-prairie region. As will be demonstrated later, these are essentially identical with Missouri prairies, and are in no wise to be distinguished from them. Along the Rocky mountains, Drude refers a broad strip of plain and foothill, comprising a large portion of Montana, western Dakota, eastern Wyoming and Colorado and western Nebraska, to a transition-region, connecting the prairies proper with the elevated plains of the Great Basin country. The eastern foothills of New Mexico are included by him in the steppe and desert region of Arizona. Topographically and phytogeographically, the foothills along the eastern border of the Rocky mountains are an intrinsic portion of the great plains, and, as such, are to be included in the prairie province. On the south, while extending the domain of the prairies to the Gulf of Mexico, Drude distinguishes the prairies beyond the Canadian river as southern prairies. It is doubtful whether he would have us consider this a region; at any rate he does not expressly term it such, as is the case with the Saskatchewan prairies. However, a glance at the flora of the geographical extremes of the prairie province will demonstrate that neither the northern nor the southern prairies are regionally distinct from the central mass, but that they merely manifest such "shading-out" as is always present toward the confines of large vegetation-regions.

Turf-builders are the most important vegetation-form for the characterization of the prairies, and in determining the floral contrast between regions, and the degree of such contrast, they are first to be considered. Of the thirty-three species of grasses which comprise the facies and the principal species of the prairie province formations, the prairies of Nebraska, Kansas, and the Dakotas possess the entire number; those of Saskatchewan, Manitoba, etc., possess thirty species; and those of the Red river country, twenty-nine species. From this it is seen that the fundament of the floral covering of the prairie province is essentially homogeneous from the northern extreme to the southern extreme. Of the thirty-six species which constitute the formational facies of the prairies, the central prairies (central in a purely geographical sense) possess the full number; the southern prairies thirty-one species; and the northern thirty-two species. Of one hundred and forty species most important with respect to frequence, abundance, or characteristic, eighty-three are common to the entire province, while one hundred and twenty-nine are found throughout the central and southern portions, and ninety-one throughout the central and northern portions. The vegetation-center of the prairies is found in Nebraska, Iowa, Kansas, and the Dakotas. From this center the typical plains flora slowly shades out toward both north and south; naturally enough over a country so little diversified with about equal rapidity. The effect of higher altitudes and greater distance from the vegetation-center accounts for the greater ultimate reduction in number of species to the northward. The fact that species of distinctly northern range are found only in one extreme of the prairie province, or those of southern origin only in the other, is of trifling importance. All vegetation regions, and none more readily than a plains region, where dissemination is so easily effected, borrow floral elements from adjacent regions, and it is only when this invasion has resulted to a pronounced degree that the original floral covering changes aspect. As has been stated above, the facies and principal species of the province are essentially the same throughout, and the comparatively small number of strictly southern, or northern species are of purely secondary importance in the consideration of the floral covering.

In the characterization of the Missouri prairie region, Drude cites *Bouteloua oligostachya* and *Bulbilis dactyloides* as the most common prairie grasses. Both of these grasses, in fact, are equaled in abundance and in importance by several species, such as *Andropogon scoparius*, *Aristida purpurea*, *Stipa comata*, *Agropyron pseudorepens*, and *Koeleria cristata*, all of which are of the widest distribution. Bulbilis, on the other hand, is entirely lacking over the vast prairies of the Saskatchewan. It may be remarked in passing that the supposed disappearance of buffalo-grass, *Bulbilis dactyloides*, connected more or less poetically with the vanishing herds of bison, is a popular myth. The buffalo-grass at the present time undoubtedly covers as large an area geographically as it ever occupied within the memory of man, and is quite as abundant over this area, except for the diminution due to artificial factors, such as the "breaking" and the cultivation of the prairies. The mistaken idea concerning the distribution of Bulbilis has arisen from the statements of trappers, scouts, and frontiersmen, who invariably confused, and still confuse, Bulbilis and Bouteloua, thus assigning to the former not only its proper geographical area and abundance, but, in addition, that of *Bouteloua oligostachya* and *B. hirsuta.* Another popular fallacy is that the blue stems, *Andropogon provincialis* and *A. scoparius,* are slowly advancing westward across the plains, an advance often connected with the supposed disappearance of Bulbilis. In fact, both species are as truly endemic in the sand hills and foothills as they are on the eastern prairies. In addition to Bouteloua and Bulbilis, Drude enumerates *Agropyron pseudorepens, Oryzopsis cuspidata, Stipa viridula, S. setigera, Andropogon Virginicus* and *A. glomeratus* as characteristic species. The last two are not found within the prairie province proper. *Stipa setigera* is common only south of the Arkansas, and *S. viridula* is abundant only along the foothills, and on the prairies of the extreme north.

That it is impossible for a phytogeographer to treat accurately the floristic and the distribution of a distant flora which he has not seen, is well exemplified in Drude's *Florenkarte von Amerika. Quercus rubra,* which on his map has a western distribution running from the southwest corner of Nebraska to the mouth of the L'eau-qui-court in the northeast, occurs in the state only in the southeast corner in the red oak-hickory formation of the Missouri woodlands. On the other hand, the western limit of *Quercus macrocarpa* does not run north and south through the sand hills, but bends to the westward, passing beyond the Nebraskan border into Wyoming and the Black hills of South Dakota. *Juglans cinerea* and *J. nigra,* which, according to Drude, scarcely cross the Mississippi, likewise occur in Nebraska. The former is found in the southeast corner of the state; the latter, as a facies of the bur oak-elm-walnut formation, extends halfway across the state along the L'eau-qui-court and the Republican.

The main features of the regional limitation and characterization, and the formations, briefly discussed in this article, are based upon a treatise entitled *The Phytogeography of Nebraska*, recently published by the authors of the present paper. The data have been extended, however, to cover the entire prairie province, while in the work referred to only the territory embraced in the political limits of Nebraska is considered.

Considering Nebraska alone, the floral covering of the state falls into four vegetation-regions: I. Wooded bluff and meadowland region; II. Prairie region; III. Sand hill region; IV. Foothill region. Region I consists of a narrow strip along the Missouri. It is an arm of the extreme western edge of the Alleghany forests, which projects northward into the prairie province as far as the Great Bend of the Missouri. Although almost surrounded by prairies, it is in no sense a portion of the prairie province. It is a portion of the Mississippi-basin region. On the central plains, especially those of Nebraska and Kansas, regions II, III, and IV are well-differentiated, both topographically and phytogeographically. As physiographic features, the prairies proper (including those of Iowa and Illinois), extending from the forest to the 98th meridian, are easily distinguished from the sand hills, and the latter, finding a general western boundary between 102–103° W., are very distinct from the foothills. To the south, in the Indian territory, the prairies proper are crowded out by the sandy plains, and the prairie region disappears, leaving regions III and IV. On the Saskatchewan plains, the forests close in on the east, and the sandy plains drop out, resulting in a similar reduction, though here it is region III which disappears. Isolated areas of sandy coteau or coulée occur more or less frequently, however, so that most of the sand hill xerophytes are represented. The more typical species, such as are characteristic of sandy fastnesses, like the Loup district in Nebraska, are necessarily lacking. As a consequence of the stronger development of region II to the northward and of region III to the southward, the division of the prairie province gives to it a peculiar dovetailed appearance. The prairie region tapers gradually to the south, finally disappearing in the Indian territory. The sand hill region likewise narrows toward the north, but much more rapidly, vanishing in the Dakotas, and attaining only occasional expression to the northward. The submontane region IV skirts the base of the Rocky mountains from Athabasca to New Mexico.

It is unnecessary to speak at length of the physiography of the three regions. The most noticeable topographic feature that gives character to the floral covering is soil composition. This, with altitude and precipitation, comprises the great factors which have brought about the differentiation of the prairies into three regions. Thus, while the prairies proper differ in the character of their gently undulating surface from the ridged and broken sand hills, and from the elevated tablelands of the foothills with their precipitous cañons, the important fact for the floral covering is that the soil of the prairie is a close loam instead of a loose sand, as in the sand hills, or an argillaceous marl, as in the foothills. Secondary to this only, is the decrease in precipitation, and the increase in altitude from the eastern boundary of the province to the western. Of equal if not greater importance for the flora is the question of environment, *i. e.*, the derivation of the floral elements. The vegetative covering of the foothills is derived primarily from the mountains, with the exception of the fundament which it has in common with the other regions. That of the prairies proper has come in part from the wooded region to the east. The flora of regions II and IV is a derived one, and the regions may be termed open. The sand hills, while they have drawn somewhat from II and IV, are at no point in direct contact with the flora of another province. The flora is to a large degree endemic, and the region is more or less closed.

The characteristic formations of the prairie province are xerophytic, occasionally poophytic. These are meadow, prairie, sand hill and foothill formations. Not infrequently, certain ruderal formations of xerophytic character acquire great prominence, as in the Niobrara district of the sand hill region. Meadow formations are never xerophytic, but always mesophytic or poophytic. Naturally, they occur throughout the three regions. The central portion of the prairie province possesses but a single type of meadow formation, the long-stemmed grass meadow, in which the facies are *Elymus Canadensis*, *Stipa spartea*, *Agropyron pseudorepens*, *Panicum virgatum*, *Andropogon provincialis*, and *Spartina cynosuroides*. This meadow formation exhibits a number of aspects in different stations. It is frequently reduced to a single facies. In sloughs and low meadows, this facies is *Spartina cynosuroides;* over certain upland meadows, it is *Stipa spartea*. The most common association of facies is that of *Elymus Canadensis*, *Panicum virgatum*, *Agropyron pseudorepens*, and *Andropogon provincialis*, which occur in meadows throughout, especially in the sand hills. The prairie and sand hill formations attain their fullest expression in their respective regions, but are not necessarily confined to them. Both prairie formations occur in the dry valleys of the sand hill region, and the bunch grass formation of region III is found upon the sub-sand hills of the prairie region. Foothill formations, on the contrary, are restricted to their proper region.

Prairie formations are of two types, the prairie grass, and the buffalo grass formation. The former covers the eastern portion of the prairie region, Illinois, Iowa, eastern Dakota, Nebraska and Kansas. The facies are species of *Sporobolus*, *Koeleria cristata*, *Eatonia obtusata*, and *Panicum Scribnerianum*. Frequently the facies of the meadow formations enumerated above assume sufficient abundance on the prairies to warrant ranking them as facies of the prairie grass formation. Like most formations of regions possessing a long growing period, the prairie grass formation manifests two different temporal aspects, a vernal and an estival-serotinal aspect. During the former, the ground-tone of the formation is due to the uniform green of its facies, which is slightly variegated by *Draba Caroliniana*, *Antennaria campestris*, *Anemone Caroliniana*, *Baptisia bracteata*, *Astragalus crassicarpus*, etc. The extremes of the estival-serotinal aspect might well be separated, if the one group did not pass so gradually and completely into the other. Two groups, the one earlier, the other somewhat later, may be distinguished, however. The former comprises *Amorpha canescens, Kuhnistera candida, Psoralea floribunda, Solidago rupestris, S. rigida, Verbena stricta, V. hastata*, etc.; the latter, *Laciniaria squarrosa intermedia, L. scariosa, L. punctata, Vernonia gigantea, Aster sericeus*, and the aianthous bloomer, *Aster multiflorus*.

The buffalo grass formation is characterized by two types, the Bulbilis type and the Bouteloua type. The geographical area of the former is large, but greatly interrupted, and, while the facies manifests great abundance, its frequence is not comparable to that of *Bouteloua oligostachya* or *Andropogon scoparius*. The dense mats of buffalo grass render this formation fairly exclusive, except where it is interrupted. The number of secondary species is small. They are for the most part reduced facies of adjacent formations, *Aristida purpurea, Agropyron pseudorepens, Distichlis spicata stricta, Koeleria cristata*, and the ubiquitous Boutelouas. The ground-tone of the formation is communicated to it by the buffalo grass. *Asclepias pumila* and *Verbena bipinnatifida*, though characteristic of this formation, have little effect upon it. *Amorpha canescens, Kuhnistera candida*, and *Solidago Missouriensis* are common in this as in the prairie grass formation. The fullest development of this formation is found in the Dakotas, and eastern Montana, from which it extends southward through Nebraska and Kansas. The Bulbilis type prevails, for the most part upon argillaceous table lands. On the other hand, the Bouteloua type is found over sandy stretches, and hence is characteristic of the transition area between the prairies and the sand hills.[1]

The sand hill formations are three, the bunch grass, the blow out and the sand draw formations. The first covers by far the larger portion of the sand hills, and sandy plains of region III; the other two are restricted to the topographic features from

[1] The facies is *Boutelona oligostachya*, replaced on the bottoms of long cañons by *B. curtipendula*. The former is scarcely less exclusive than Bulbilis in typical situations, where it composes from 92 to 98 per cent. of the vegetation. In the transition area between regions II and III it admits a number of secondary species, such as *Solidago mollis, Lygodesmia juncea, Plantago Purshii*, etc.

which they are named. The bunch grass formation exhibits two types, the blue-stem formation, which reaches its chief development in the sand hills proper, and the beard grass formation, which is characteristic of sandy plains and sub-sand hills. Both are open formations of a pronounced type; in the first, the individuals are 1–3 meters apart. Owing to the xerophytic nature of these formations, not only are the grasses bunched, but nearly all principal and secondary species assume the tufted habit. An additional characteristic directly traceable to the same conditions is the exceedingly long tap root developed by most sand hill inhabitants. The facies of the blue-stem formation are *Andropogon scoparius*, *Stipa comata*, *Calamovilfa longifolia*, and *Andropogon Hallii*. The first is the most characteristic on account of the striking bunches which it forms. *Stipa comata* is especially frequent and abundant. In certain situations, both are to a considerable extent replaced by *Calamovilfa longifolia*, *Andropogon Hallii*, and even at times *A. provincialis*, all of which except the last occur throughout the formation. The secondary species are *Eragrostis trichodes*, *Oryzopsis cuspidata*, *Muhlenbergia pungens*, *Bouteloua hirsuta*, *B. oligostachya*, *Sporobolus cryptandrus*, and *Cyperus Schweinitzii*. Important modifications of this formation are imparted to it by the sand-cherry, *Prunus Besseyi*, prairie rose, *Rosa Arkansana*, *Amorpha canescens*, *Ceanothus ovatus* and *Yucca glauca*. The number of secondary species is so great that only the most conspicuous can be mentioned: such are *Cycloloma atriplicifolium*, *Froelichia Floridana*, *Eriogonum annuum*, *Chrysopsis villosa*, *Eriocarpum spinulosum*, *Opuntia humifusa*, *Cactus viviparus*, *Psoralea lanceolata*, etc.

The facies of the beardgrass formation are *Aristida purpurea*, *A. basiramea*, and *Sporobolus cuspidatus*, and more rarely *Stipa spartea*. Where this formation touches the bluestem formation, there is necessarily an intermingling of facies. Secondary species of grasses are very much the same for both formations: *Eragrostis pectinacea*, *Panicum Scribnerianum*, *Aristida oligantha*, *Koeleria cristata* and *Eatonia obtusata* are usually more abundant in the beardgrass type. Of other secondary species, in addition to those enumerated in the blue-stem formation, are *Helianthus petiolaris*, *Potentilla arguta*, *Argemone alba*, *Plantago Purshii*, *Linum rigidum*, etc.

The blowout formation is restricted to peculiar crateriform hollows formed by the action of the wind, and termed "blowouts." In its young and typical condition, it is the most open of all plains formations. It occurs, of course, only in the sand hills proper, since it is here only that blowouts are formed. The facies of the formation are *Redfieldia flexuosa*, *Muhlenbergia pungens*, *Eragrostis trichodes*, *Oryzopsis cuspidata*, and *Calamovilfa longifolia*. The colonization of a recently formed blowout is brought about by means of *Redfieldia flexuosa*, which is uniformly the first grass to make its appearance in these hollows of shifting sand. The slight stability imparted to the sand by it enables *Muhlenbergia pungens* and *Eragrostis trichodes* to secure a foothold. These are followed by other grasses, and then by such secondary species as *Tradescantia Virginica*, *Eriogonum annuum*, *Meriolix serrulata*, *Lathyrus ornatus flavescens*, *Phaca longifolia*, and *Euphorbia petaloidea*. By this time the sand of the blowout has ceased to shift, and a host of ordinary sand hill inhabitants appear, resulting in the complete reclamation of the blowout and the decadence of the formation which characterized it. The process of reclaiming a blowout is very gradual, and the period between the incipience and the decadence of such a formation is often as much as ten years.

The sand draw formation has much in common with the blowout formation. It is less frequent, however, and is not so well characterized. Oddly, the grasses are not the controlling species. Their place is taken by *Cristatella Jamesii*, and *Polanisia trachysperma*. In a typical sand draw, the grasses are represented only by scattered tufts of *Munroa squarrosa*, *Eragrostis major*, *Sieglingia purpurea*, and *Paspalum setaceum*. The most frequent secondary species are *Euphorbia petaloidea*, *E. hexagona* and *E. montana*.

The foothill formations are three, (1) the undershrub formation of table lands and bad lands, (2) the mat and rosette formation of buttes and hills, (3) the grass formation of high prairies and sandy plains. The undershrub formation is not peculiar to the foothills of the prairie province; it here covers but a small area in comparison with the vast stretches occupied by it in the Great Basin province. In the foothills, this formation exhibits two types, the one confined to high, somewhat grassy table lands, the other found solely on alkaline lands, or bad lands. The former may be termed the sagebrush type, the latter the greasewood-white-sage type. The facies of the sagebrush formation are *Artemisia tridentata*, *A. frigida*, *A. filifolia*, *A. canadensis*, and *A. cana*, *Chondrophora Howardii*, *C. nauseosa*, and *C. Douglasii*, and *Gutierrezia Sarothra*. The grasses are species of *Bouteloua*, *Agropyron*, and *Koeleria cristata*. The facies of the greasewood-white-sage formation are *Sarcobatus vermiculatus*, *Eurotia lanata* and *Atriplex confertifolia*. Grasses are practically absent. Other secondary species are few. *Ptiloria tenuifolia*, *Aster multiflorus*, *Cryptanthe Fendleri*, and *Chrysopsis villosa* are the most important.

In the foothills of the central portion of the prairie province, the mat and rosette formations are the most widely distributed. Mats and rosettes have almost exclusive control of buttes, cliffs, rocky ridges, and sandy hillsides. Two types may be distinguished, the mat formation of buttes and cliffs, and the rosette formation of sandy hillsides. No well-marked group of facies is regularly present. The ground-tone of the mat formation is derived from a large number of mat-forming species, *Arenaria Hookeri*, *Gilia spicata*, *Orophaca caespitosa*, *Eriogonum cernuum*, *E. flavum*, *Gilia iberidifolia*, *Phlox Hoodii*, and *Homalobus montanus*. The secondary species are for the most part invaders from the sand hills, such as *Meriolix serrulata*, *Malvastrum coccineum*, *Rumex venosus*, *Psoralea lanceolata*, *Aristida purpurea*, *Muhlenbergia pungens*, etc. The rosette formation takes its character from *Polygala alba*, *Paronychia Jamesii*, *Pentstemon albidus*, *P. caeruleus*, *Phlox Douglasii*, and *Oreocarya suffruticosa*. This formation is, in reality, transitional between the mat and the grass formations of the foothills, and its secondary species are derived chiefly from them.

The grass formations are more or less intermediate between the sand hill and the foothill formations, and serve to connect the two regions. The facies are two, *Stipa comata* and *Agropyron pseudorepens* each giving character to a more or less distinct type. The Stipa formation predominates over high prairies, the Agropyron formation upon level, sandy plains. The first exhibits a striking group of secondary species, which, from their constant association, and the uniformly blue color of their flowers, lend a distinctive character to the formation. These are *Lupinus plattensis*, *Astragalus mollissimus*, *A. adsurgens*, *Spiesia Lamberti* and *Psoralea argophylla*. The Agropyron formation is much more open than the preceding, and is of a more indefinite type.

Halophytic and ruderal formations play a more or less prominent part in the constitution of the floral covering of the prairie province, but they are rarely characteristic, and hence scarcely within the scope of a short paper.

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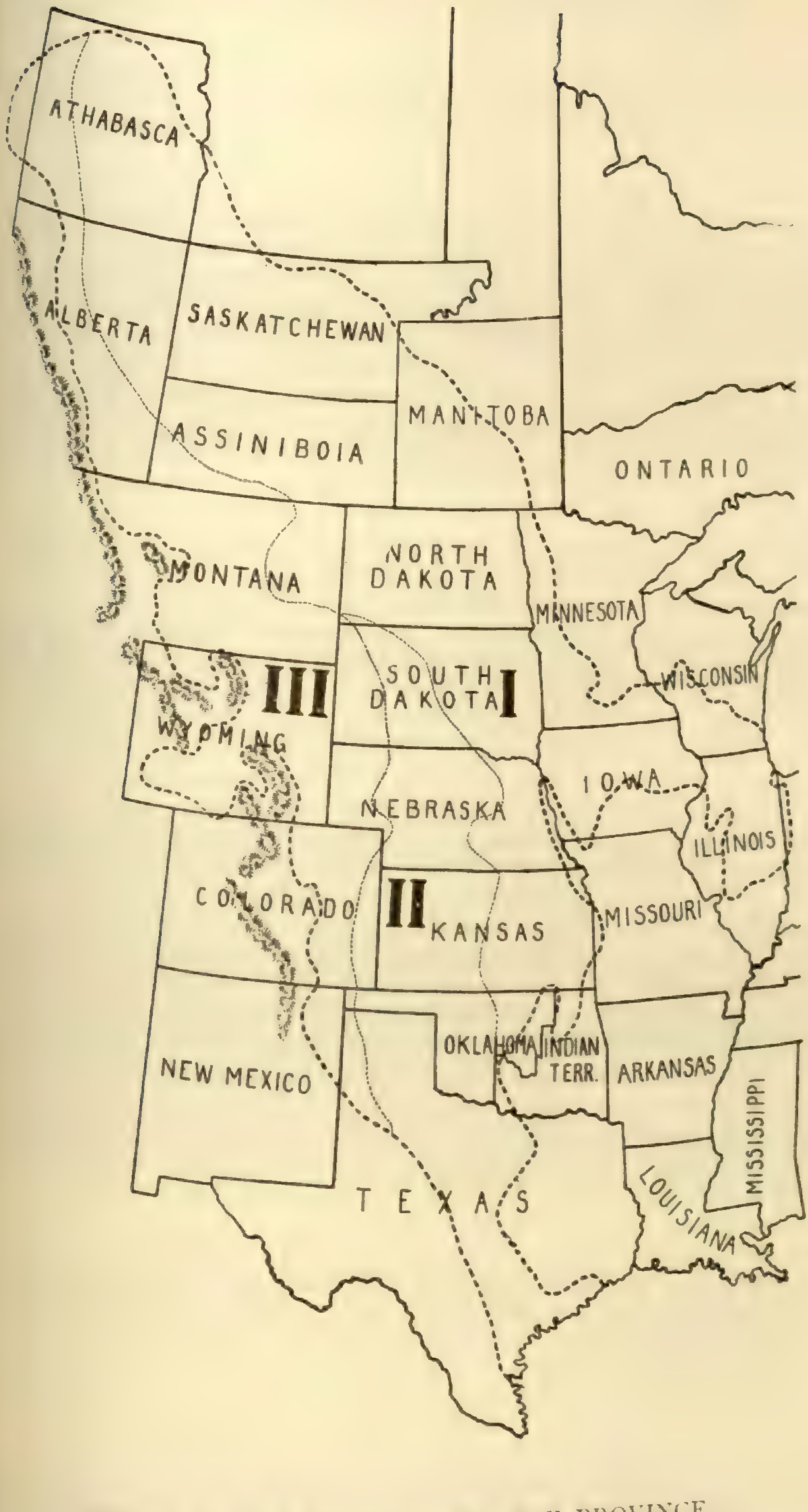
EXPLANATION OF PLATE XXI.

Sketch map of the "Prairie Province:" I, the prairie region; II, the sand hill region; III, the foothill region.


ATHABASCA
ALBERTA
SASKATCHEWAN
MANITOBA
ASSINIBOIA
ONTARIO
NORTH DAKOTA
MINNESOTA
MONTANA
III
SOUTH DAKOTA
I
WISCONSIN
WYOMING
IOWA
NEBRASKA
ILLINOIS
COLORADO
II
KANSAS
MISSOURI
OKLAHOMA
INDIAN TERR.
ARKANSAS
NEW MEXICO
MISSISSIPPI
TEXAS
LOUISIANA

POUND and CLEMENTS on PRAIRIE PROVINCE.

OBSERVATIONS ON THE NUTATION OF HELIANTHUS ANNUUS.[1]

JOHN H. SCHAFFNER.

In the year 1890 Kellerman[2] reported some observations on the nutation of the sunflower, in which he concluded that, contrary to an almost universal popular belief, the heads of *Helianthus annuus* do not turn with the sun, facing toward the east in the morning and gradually moving westward until evening. He considered the belief mainly traditional, although he found some movement through a very small space, but rarely if ever through a space approaching a half circle. He suggested, however, that nutation might be more marked in the head previous to anthesis.

Having been a firm believer in the supposed nutation, and recalling numerous instances which seemed to support the belief, the writer desired to ascertain for himself the true facts in the case and also the conditions which may have given rise to the traditional belief. Accordingly a long series of observations were made in Clay county, Kansas, during the summers of 1896 and 1897, extending in both years from June to September. The summer of 1896 was especially favorable for the study, there being a more abundant and luxuriant crop of this characteristic western weed than usual. The western variety of *Helianthus annuus* differs considerably in many anatomical characters from the common cultivated variety which was not included in the study. The observations of the second season were entirely a confirmation of those recorded during the first.

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[1] Contributions from the Botanical Laboratory, Ohio State University. II.

[2] Observations on the nutation of sunflowers. Trans. Kan. Acad. Sci. **12**: 140–158. 1889–90.

NUTATION OF THE GROWING PLANT.

The observations were commenced on plants from three to five feet high, with stems varying from a half inch to an inch and a half in diameter. Observations were taken on a large number of individual plants, as well as on large patches of plants in general. In the morning, at sunrise, when the weather is clear, the plants all nutate toward the east or northeast at an angle of 45° to 75° from the vertical. The leaves stand out with rigid petioles so that their upper surfaces face the morning sun. When one stands looking toward the west, all the terminal buds and upper leaf surfaces face him. As the sun rises from the horizon, the plants gradually become erect and the leaves move at the same time so as to present their upper surfaces directly at right angles toward the rays of light. At noon the stems and terminal buds are vertical. During the afternoon the tops gradually nutate towards the west at an angle of 60° to 90° from the vertical. Usually the nutation is 90°. The upper surfaces of all the upper leaves have changed their positions so that they face due west and all those near the terminal bud have thus a more or less vertical position. The bending of the stem usually takes place about four or five inches from the tip and the curve represents merely the quadrant of the circumference of a circle, although sometimes it is more abrupt and angular (*fig. 1*).

By about 10 o'clock P.M. most of the stems have regained the vertical position, but at this time some may still be curved toward the west from 20° to 40°. The leaves now are turned downwards, drooping in such a manner that the apices all point vertically toward the earth. The curving is mainly in the petiole. This "sleeping" position contrasts quite strikingly with the day position, and it is taken both on cloudy and on starry nights. About 2 o'clock A.M., and usually much earlier, the leaves begin to be raised, and the tops of the stems turn toward the east gradually until sunrise, when they are again nutating from 45° to 75° toward the east.

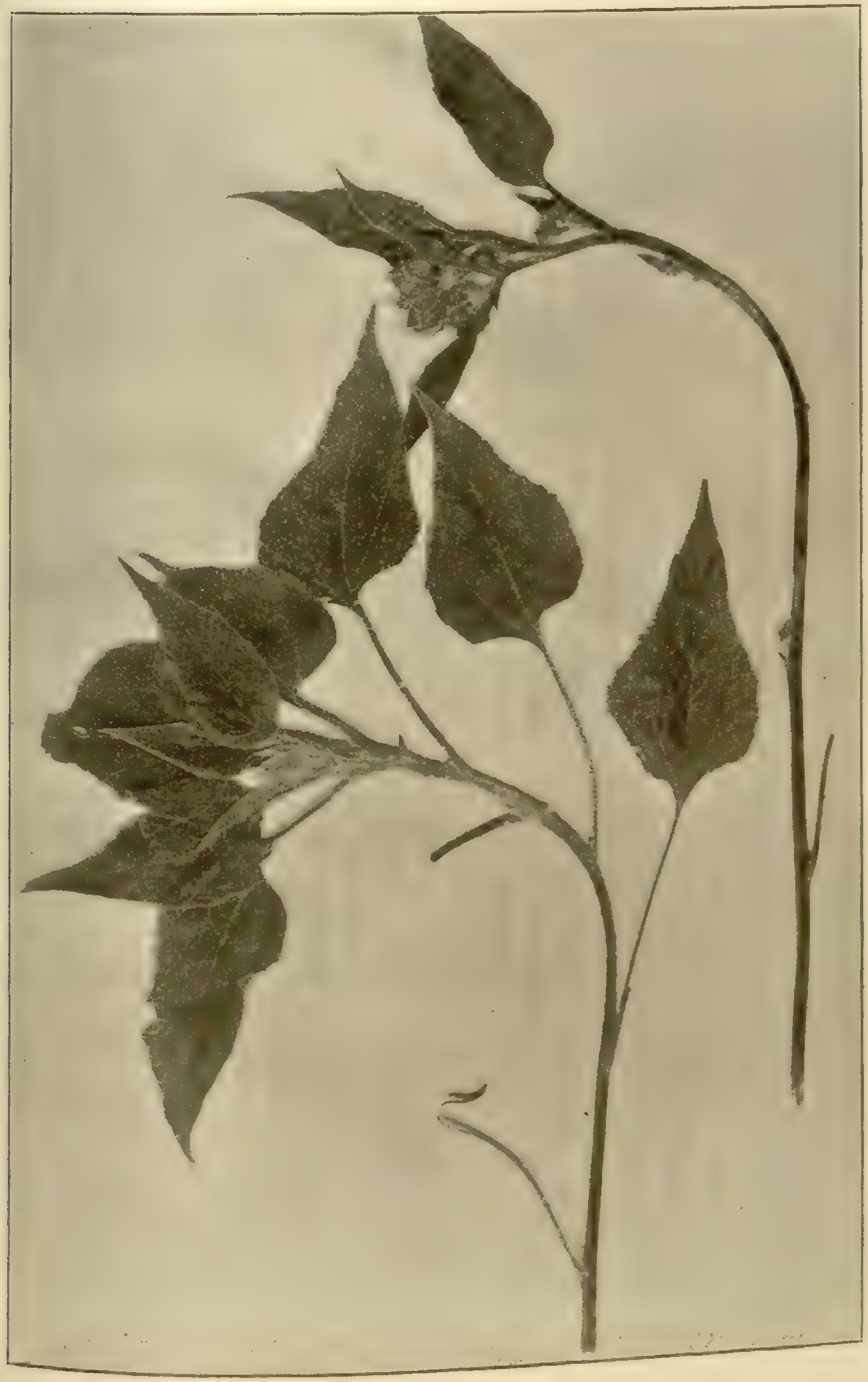

FIG. 1.—Two small plants of Helianthus showing westward nutation at sunset; photographed from pressed specimens with the natural curvature.

The following is a typical table of the nutation during twenty-four hours. July 11–12, 1897; two days after rain; sunshine and full moonlight throughout the period of observation; moderate wind from the northeast.

Time	Temperature	Angle of nutation	Direction	Remarks
5 p. m.	28° C	35°	West	Sunshine
6 p. m.	27	60	West	Sunshine
7 p. m.	24	75	West	Sunshine
Sunset				
8 p. m.	21	90	West	Full moon
9 p. m.	19	70	West	Full moon
10 p. m.	19	40	West	Full moon
12 m.	19	0	Vertical	Full moon
1 a. m.	19	30	East	Full moon
Sunrise				
5 a. m.	16	55	East	Sunshine
6 a. m.	17	70	East	Sunshine
7 a. m.	18	70	East	Sunshine
8 a. m.	19	40	East	Sunshine
10 a. m.	21	20	East	Sunshine
12 m.	22	0	Vertical	Fleeting clouds
2 p. m.	23	15	West	Fleeting clouds
3 p. m.	23	20	West	Fleeting clouds
5 p. m.	22	40	West	Fleeting clouds

There are thus four distinct periods in the daily nutation of the plant.

1. From shortly after sunrise, when the plant is nutating about 60° east, until sunset there is a gradual movement westward until the terminal bud faces west and the upper part of the stem nutates 90°.

2. From sunset until about 10 o'clock P.M., during which time the plant regains its vertical position and the leaves drop downward so that their apices point vertically toward the earth.

3. From 10 o'clock P.M. to 1 o'clock A.M., the period of repose.

4. From 1 o'clock A.M. until sunrise, a gradual turning eastward, accompanied by a rising of the leaves by which they are

again brought with their upper surfaces at right angles to the light.

Of course there is considerable difference to be observed in different individuals. Some regain the vertical position after sunset much sooner than others, and some begin to turn eastward long before 1 o'clock A.M. The nutations described here are not exceptional, but under ordinary conditions they occur in nearly all individuals, some nutating more prominently, however, than others. As soon as side branches are developed they partake of the movements to nearly as great an extent as the main axis.

If the bending of the stem and the diaheliotropism of the leaves is due to the direct stimulus produced by sunlight, then it is easy to see why the nutation should be considerably less in the morning than in the evening, since the light has much less time to produce the stimulus. But it may be that other causes have an influence on nutation. Thus at 11 o'clock P.M., while the leaves are all drooping, the crowns can frequently be seen turning toward the east which just two hours before were nutating 90° west. At 1 o'clock A.M., when it is evident no direct light can come from the sun, the tops of the stems are frequently seen nutating toward the east 30° or more, and the leaves are beginning to rise and stand up rigidly. Nor does it seem that the period of repose is brought on entirely by the falling of the temperature. From sunset until midnight there is a rapid fall in temperature, and during this period the "sleep" position is assumed. But there is also a rapid fall from 1 o'clock A.M. until sunrise, when the plant responds exactly in the opposite way. The drooping of the leaves then is not to be explained entirely as a means of protection against excessive radiation, for when the temperature is the lowest the leaves are already standing up rigidly and turning toward the east. Whether fluctuations in the humidity of the atmosphere had anything to do with this action, I did not attempt to investigate. I believe that this action is largely due to the fatigue of the protoplasm which must have expended an enormous amount of energy to keep up the turgidity of the cells in the petiole during the day, and it resumes its work, after a period of rest, long before there seems to be any direct stimulus from the light.

EFFECT OF WIND, CLOUDS, DRYNESS, AND MOISTURE.

A moderate wind has little or no effect on nutation, no difference from what direction it comes. In Kansas the wind is very variable, but no important effect could be detected. However, when the wind blows very strongly it interferes somewhat with nutation. On some days when there was a very strong southwest wind the plants still turned west from 70° to 90°.

Cloudy weather has little effect on nutation. However, on some days it seems to check it a little. On some days, as for instance on July 27, 1897, it was cloudy nearly all the afternoon, but there was a strong nutation of 90° to the west.

Continued drought has a marked effect on nutation. When the ground is dry and the weather clear and hot the plants wilt, the leaves droop, and there is little or no nutation of the stem.

During rainy weather on cloudy days the nutation in the evening was scarcely noticeable. Also on a rainy day with sunshine in the latter part of the afternoon little or no nutation was discovered. When the ground was saturated with moisture and the atmosphere was very humid, although clear, very little nutation was observed. Thus in rainy weather, nutation is checked when it cannot be ascribed to a lack of sunshine. This was especially noticeable in the evening, but it was also very marked on mornings when the ground and atmosphere were saturated. When the ground is moderately moist and the air clear and dry with a light breeze, the conditions for nutation are at the optimum. At such times it is simply astonishing to notice a sunflower patch just at the setting of the sun. It thus appears that excessive moisture interferes greatly with the normal nutation of *Helianthus annuus*. This agrees with the observations of Cunningham,[3] who finds that plants react least readily to stimuli in a saturated atmosphere.

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[3] The causes of fluctuations in turgescence in the motor organs of leaves. Ann. Roy. Bot. Gar. Calcutta **6** [Part 1, 4to. pp. 161]. 1895.

EFFECTS OF DECAPITATION, DEFOLIATION AND WOUNDING.

In order to determine through what organs the stimulus was received which caused the stems to bend, the terminal buds of a large number of plants were removed, and it was found that this treatment had no effect whatever, at least no noticeable effect, on the daily nutation. The decapitated plants acted in the same way as others not thus treated, nutating from 40° to 60° in the morning and from 60° to 90° in the evening. When conditions were favorable the decapitated plants nutated 90° west in the evening both on the day on which the operation was performed and for any number of days afterward.

Plants were also wounded by cutting slices from the side of the stem midway between the terminal bud and the central point of curvature, both on the east side and on the west. But this seemed to have no more effect on the nutation than would follow from the mechanical interference caused by the wound.

Plants were next treated by cutting off the leaves. In some the leaves were cut close to the stem, while in others the laminæ were cut off, the petiole being left. Plants thus treated immediately lost their power of nutation. They would stand perfectly upright, while their neighbors not so treated would nutate 90°. Some delaminated in the evening were found to be still inclining toward the west in the morning, while others had regained the upright position. When the leaves were cut in the morning the plants were found to be perfectly upright in the evening, while the natural ones and some decapitated the same morning nutated 90° west.

Thus it appears that decapitation has no effect on nutation. Wounding the side of the stem affects nutation only to the extent that it produces mechanical interference. Delamination, whether of the blade or of the entire leaf, stops nutation entirely. It was observed in some plants which had been delaminated that after the leaves and stems of the terminal bud had grown out again nutation was continued in the new parts, but the bending was confined to those parts and did not extend below.

From the above it is demonstrated that the irritability which is responsible for the bending of the stem is not inherent in the stem itself, but the stimulus is received by the lamina of the leaf, and the impulse transmitted through the petiole to the stem produces a response from both these parts.

NUTATION OF THE HEADS BEFORE ANTHESIS.

About July 15 the behavior of the young heads began to be observed. It was found that both the terminal heads and those on side branches nutated to the same extent as the leaf buds. Young heads on long, naked stems coming from the axils of leaves nutated also, the bracts of the involucre acting no doubt the same as the ordinary leaves. When the leaves were removed from the stems bearing heads, the nutation did not cease. Thus, on August 2 the leaves were removed from plants having young heads, and the next day these nutated 50° east in the morning, and 90° west in the evening. This experiment was repeated many times with both terminal and lateral heads, always with the same results. After the leaves have been removed from a plant having forty or fifty heads the effect of the nutation becomes quite striking.

THE DISK DURING ANTHESIS.

The nutation of the heads continues until anthesis begins. At this time the stem below the head hardens, which makes further nutation impossible. During anthesis the head is tipped sidewise until it stands with its face almost vertical, and this nodding is nearly always toward the northeast, although it may be east or north also. During favorable weather, at least 90 per cent. of the open disks will be found facing the northeast, both in the morning and in the evening. The heads are not disturbed by light wind, but a strong wind twists the stems and thus greatly disturbs the normal position of the heads. Whole acres of plants were observed in regard to these points. The eastward position of the disks readily deceives one into thinking that the face moves with the sun, especially when observations are taken only in the morning. The nodding of the heads takes place about the time when the ligulate florets have all expanded; sometimes, however, it begins earlier. When the disk nods toward the northeast, the bracts of the head are brought with their outer surfaces into the most advantageous position for the process of photosyntax, and can thus continue to manufacture food which can no longer be transferred so readily through the elongated and hardening stem. This is of great advantage to the developing seeds of the large disk. There is also another advantage. The disk is turned away from direct sunlight, bringing the conditions to an optimum for the processes of pollination and fertilization.

Meehan[4] has observed an eastward turning of the heads of *Helianthus mollis*. He states that it has a southeasterly face on opening, and that it turns not with the sun but eastwardly as the head progresses toward maturity.

HELIANTHUS RIGIDUS.

During the summer of 1897, observations were also made on the nutation of *Helianthus rigidus*. Nutation in this plant is even more marked than in *H. annuus*. Young leafy stems and some with young heads were observed to nutate from 70° to 80° east in the morning and 90° west in the evening. The point of bending is quite low, usually about eight inches from the tip. Because of the naked and slender stems which bear the heads and the vigor with which they nutate, this plant should be an exceedingly favorable object for the study of curvature in stems, since it could be manipulated almost as readily as can the roots of seedlings.

COLUMBUS, OHIO.

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[4] BOT. GAZ. 9: 49–50. 1884.

ON THE MODE OF DISSEMINATION AND ON THE RETICULATIONS OF *RAMALINA RETICULATA.*

GEORGE JAMES PEIRCE.

SEVERAL years ago, Professor W. G. Farlow, of Harvard University, suggested my examining the thallus of *Ramalina reticulata* Krplhbr., with a view to determining the origin and mode of growth of the holes which give to this plant its characteristic appearance and its name. He generously allowed me to use all the material which was in the herbarium, but for various reasons I failed to obtain any results.

On coming here, I was surprised to find the white and blue oaks (*Quercus alba* L. and *Q. Douglasii* Hook. & Arn.) festooned with this lichen to such a degree that many even young and small trees are as hoary in appearance as old New England pines overgrown by *Usnea barbata* Fr.[1] The live oaks (*Q. chrysolepis* Liebm.) of this vicinity are seldom the resting place of other than fragments of nets torn by storm and wind from other trees and blown to them. As a rule, the evergreens, whatever the shape of their leaves, have fewer fragments or whole plants of Ramalina growing upon them than deciduous-leaved plants. It would be a long and useless task to determine the species of shrubs and small trees which, forming the thickets on the borders of the creeks, and composing the "chapparal" covering parts of the foothills, are draped more or less by large or small fragments of Ramalina which have been caught in winter by their leafless branches, or on which the younger nets have grown from the spore. The reasons why *Ramalina reticulata* is found hereabouts on deciduous-leaved trees and shrubs almost exclusively are obvious: namely, that there is less chance of fragments catching on branches covered by leaves than on bare and rough ones; and if any fragments should catch on leafy branches, they would receive less light during the winter rains than those hanging from unshaded branches, and hence, as the elaboration of non-nitrogenous food by the gonidia would be less, so also the growth of the association of hyphæ and gonidia would be proportionally less. However, nearer the coast and southward, there is not this distinction, for this lichen grows on trees and shrubs of all sorts in that milder region, where during the dry and leafy season frequent fogs make some food manufacture and growth even then possible. About here it grows with little competition and attains a startling size, but there it is crowded by Usnea, Cladonia, etc., and remains, so far as my own observations go, much smaller in size. I have a fragment, collected very near here, which is twenty-six inches long, measured dry. There is no means even of guessing how much longer the whole plant would have been. So far as I know, this species of Ramalina is the longest lichen however, and as the breadth of the fragments is never very small in proportion to their length it may come near being the broadest also.

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[1] The accompanying figure shows a white oak overgrown by *Ramalina reticulata.* The photograph of which this is a reproduction was very generously taken for me by one of my students.

MODE OF DISSEMINATION.

By all means the commonest and most effective means by which *Ramalina reticulata* is reproduced and distributed is by larger or smaller pieces being torn by the wind from plants firmly attached, and carried to trees or shrubs, on the bare, rough branches of which the fragments catch and stay (fig. p. 405). As will be shown later on, this lichen softens to a remarkable degree when wet, it absorbs much water and greatly increases in weight, and its netted structure and branching habit cause it to be easily torn as it hangs down like a soft, delicate piece of gray-green lace, always longer than it is broad. When dry, it is hard, stiff, tenacious, and elastic, not readily broken by the wind. When wet, it is soft, pliant, not especially tenacious or elastic, and it is *much* heavier. As a rough index of the increase in weight during a hard and protracted rain the following figures will serve.

Fragment air dry weighed - - -	0.499 gr.
" soaked 15 min. in cold[2] water and surface dried by filter paper, weighed - -	1.020 gr.

Weight wet: weight dry = 2.04 : 1.

This increase in weight is less than that which would occur in nature, for more water would there adhere to the surface of the lichen than was left by the filter-paper. The increase in weight is furthermore unaccompanied by any immediate increase in strength,[3] for it is impossible that growth should occur so promptly or so rapidly as to keep pace with the increase in weight, although the wetting and consequent increase in weight take place more slowly in nature, even in a hard rain, than when the lichen is immersed in water in the laboratory.

The rains come only in winter, when the branches of many trees and shrubs are bare of leaves, and roughened by buds and barky excrescences. The rains are usually accompanied by wind, often high wind. It is therefore easy to see that the tearing away by the wind of fragments from the soft, heavy, pendant masses of lichen is inevitable, that the catching of these, often with a double twist which fastens them securely on bare rough branches, is very likely to occur ; and when the rain ceases, and

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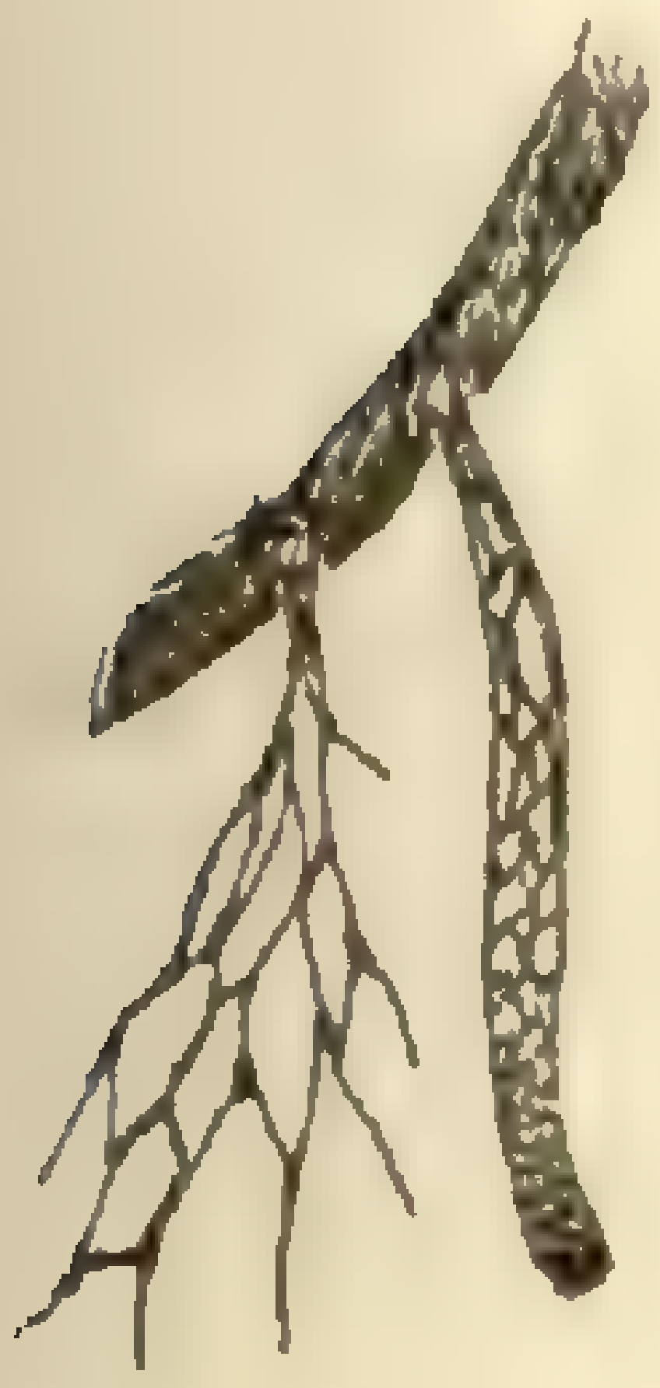
[2] Cold water to avoid possible solution of gelatinous matter.

[3] For the actual decrease in strength see p. 415.



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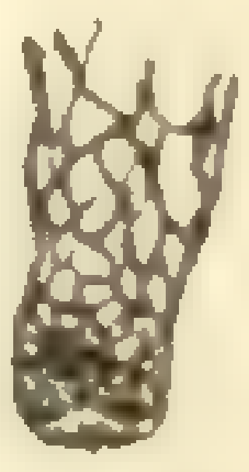

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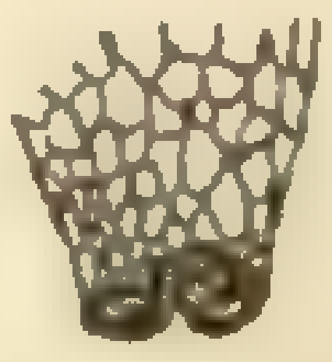

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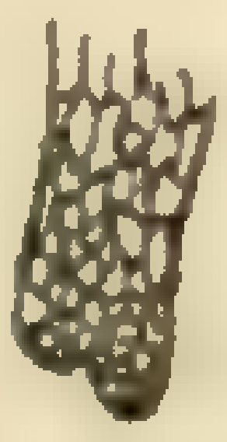

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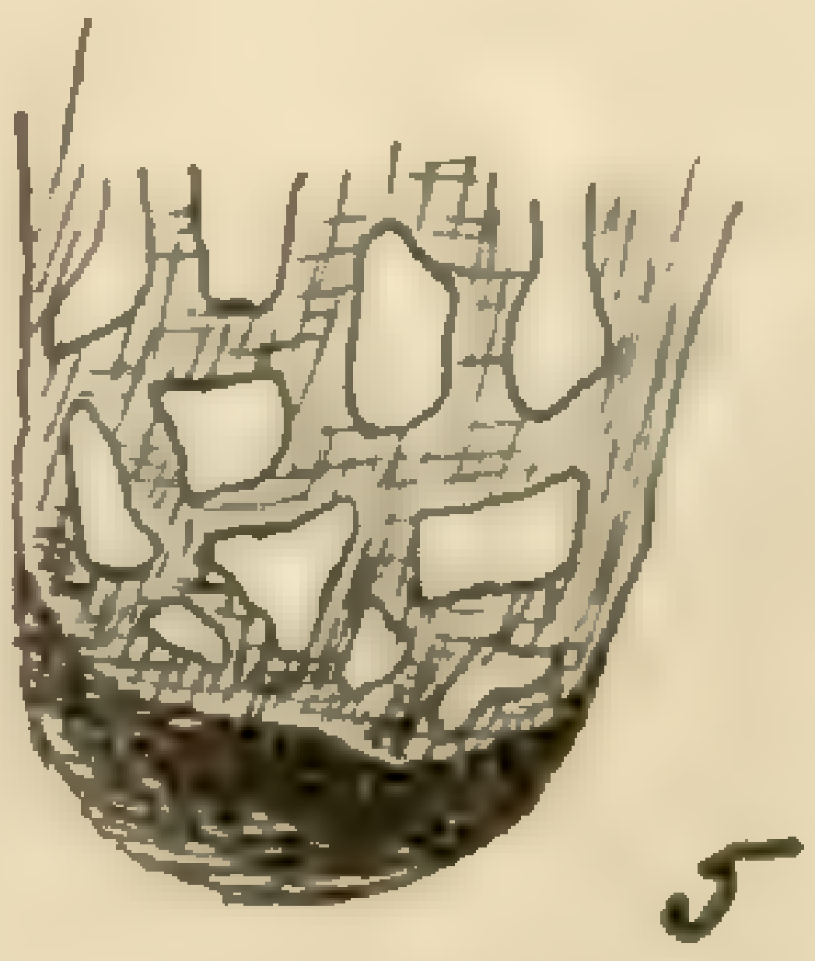

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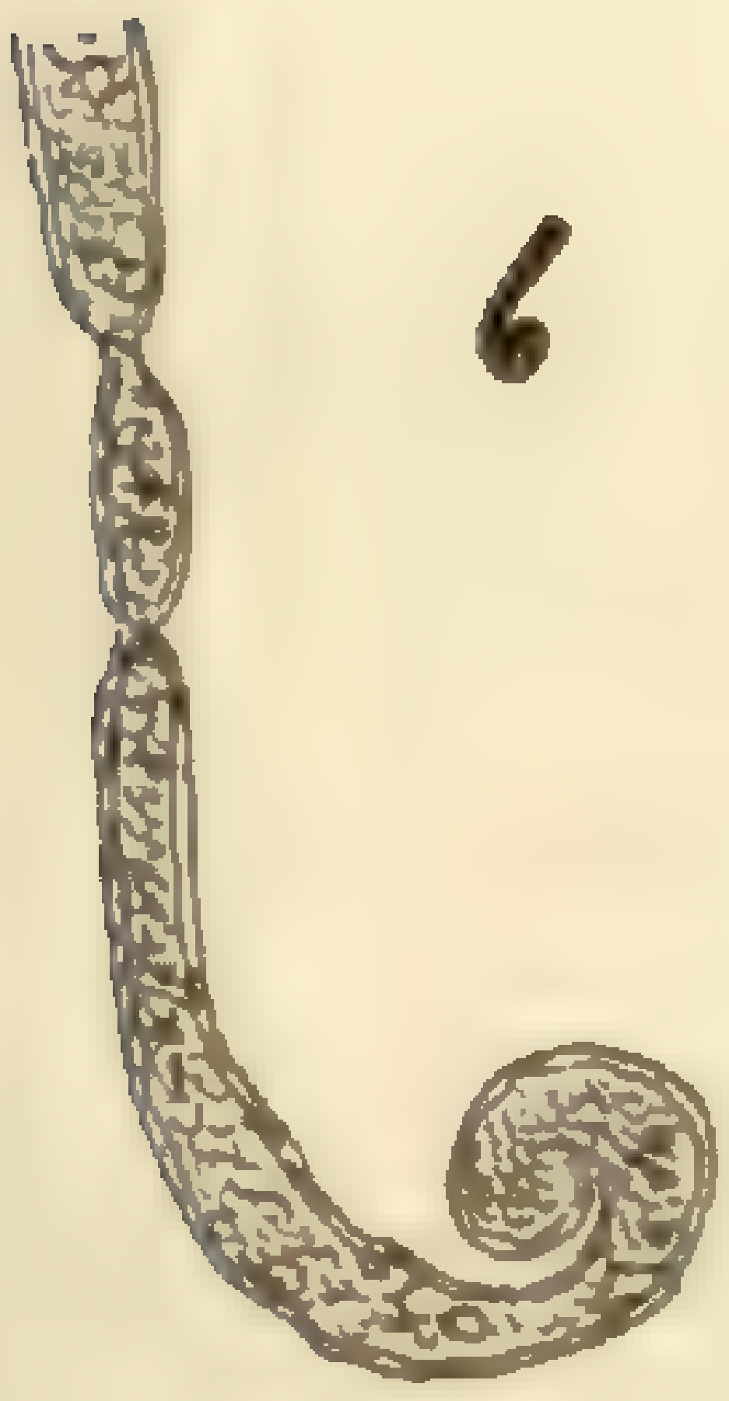

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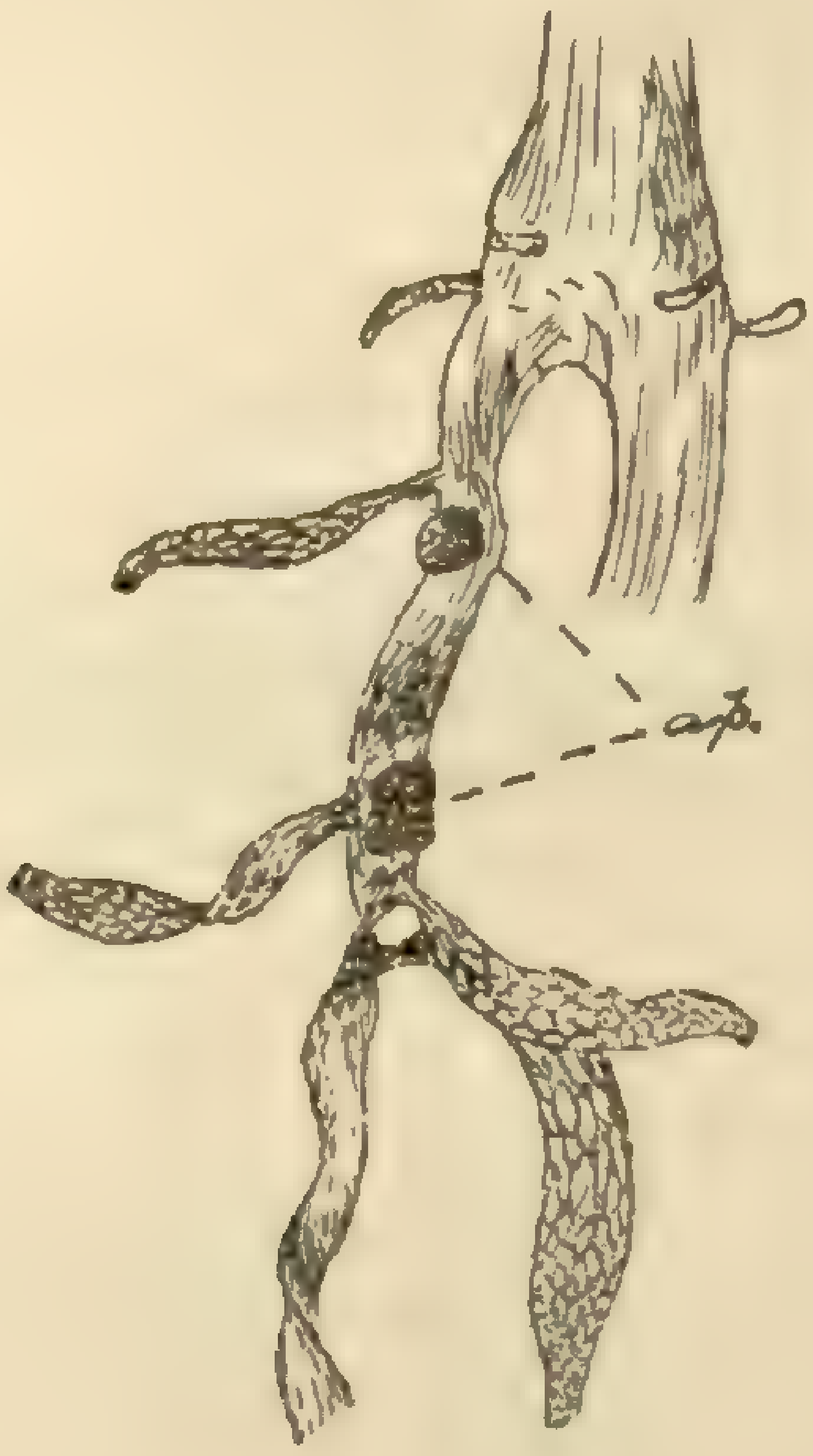

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G.J.P. del.

Fig. 1. Two young thalli of *Ramalina reticulata* which have grown from spores on a small branch. The left hand thallus has been broken, the right hand one is younger and still intact. Natural size.

Figs. 2, 3, 4. Ends of branches, showing narrower, backwardly rolled tips: 3 and 4 showing showing forking, in 3 with equal growth, in 4 with unequal growth of the branchlets, each with its own tip. × 3.

Fig. 5. Tip. × 15.

Fig. 6. Tip in section, showing circinate rolling. × 96.

Fig. 7. Part of a large thallus, showing apothecia (*ap*), and branches of various sizes, on the broad strands bounding a large mesh. Natural size.

the lichen dries, it contracts somewhat where it has been caught, as well as along its whole length and breadth, and so holds still more tightly to its support. It thus remains firmly fixed till the next rain comes. It may be dislodged again, for such fragments do not form even the small weak holdfasts developing on specimens which have grown from the spore (fig. p. 407). The dislodgement is, however, less common than one would at first imagine ; *first*, because of the "double turn" which is so common, and *second*, because the part thrown around the branch remains more or less fixed in shape, conforming to the branch somewhat as a tendril does to its support. That there is anything more than a mechanical reason for this I doubt, although there may be contact or chemical irritation at this point ; for even when thoroughly wet, the part of the lichen bent or coiled around a branch does not uncoil or become very loose. Whether this is simply the fixing of a certain form by the growth, completed under mechanical stress, of the part of the lichen bent around the branch, or whether the growth is modified, directed, prolonged and finally terminated by the irritation set up by contact with the branch, I am not now able to say. Experiment only can settle this point, and experimentation with lichens is peculiarly difficult because of their slow growth. Against the idea that there may be irritation (contact or chemical), and a response thereto on the part of the hyphæ, is the fact that these hyphæ do not grow out from the lichen and attach themselves to the bark, there is no formation of anything like a new foot or holdfast such as the young lichen forms when growing from the spore. It is necessary, however, to consider the effect of contact with a branch not only upon the hyphæ which touch it, but also upon the the gonidia and hyphæ which may receive more or less nutritious solutions from the dead and decaying bark-cells. Observation leads to the belief that the fragment is simply caught by a rough branch, twisted about this by the wind, and remains there indefinitely, or until, during some subsequent rain, it becomes detached, falls to the ground, or is blown away to another branch.

The growth of any part of the lichen seems not to be impaired by detaching it from any other part. The fragments torn and carried away by the wind grow and fruit perfectly well ;

indeed it is a difficult matter (if possible at all) to find a whole fruiting specimen of *Ramalina reticulata*. I have not done so. The only specimens showing the holdfasts which I have been able to find, are small, the largest only seven inches long, (measured dry). Judging by the size of these holdfasts, it is hard to believe that they would grow strong enough to hold plants much longer; and of course the rest of the thallus is as weak as the holdfast, and that it breaks readily has just been shown.

Plainly then the usual and most effective mode of reproduction and distribution of *Ramalina reticulata* is a vegetative one, the rain softening the thallus and making it possible for the wind to detach pieces, even of considerable size, which are then carried (a large proportion of those detached) and fastened more or less securely by the wind upon branches of trees and shrubs, where the fragments thrive as if always undisturbed.

THE RETICULATED THALLUS.

The characteristic feature in the habit of *Ramalina reticulata* is, as the name implies, its netted structure. From the youngest and smallest to the oldest and largest, these Ramalinas are all of them nets. The youngest (and the young branches reproduce this) are shaped something like a narrow spatula (*figs. 1, 2*). Just behind the backwardly rolled and somewhat narrower tip, the flat thallus begins to be perforate, these perforations increasing in size to near the base of the thallus. There they are decidedly smaller, finally disappear, and the thallus contracts into a single thickened strand, which enlarges at the base. The stalk of a branch is very short and is confluent with the thallus (*fig. 7*, also *figs. 3* and *4* where branching is taking place). In the young Ramalinas which have grown from the spore, on the branches of trees, etc., the stalk may be somewhat longer and slightly broadened at the base into a small flattened, discoid holdfast (*fig. 1*). Since neither the stalk nor the holdfast keeps pace with the growth of the net-like part of the thallus, it is easy to see that the increasing weight of the last will sooner or later result in the lichen being broken or torn into two pieces.

This lichen does not form soredia. Other than the strictly vegetative mode of reproduction, which has been described in the foregoing, the only mode is by spores. The apothecia in which these are produced form on all older, though not necessarily oldest, parts. Either a very few comparatively large ones are produced on the flat, narrow strands forming the coarser nets, or a few still larger ones are scattered over the broad, usually short, plates, from which many branches spring, or finally a great number of small ones arise on similar, but older, broad expanses. The apothecia usually form on the flat surface rather than on the edge of the thallus, thus exhibiting a tendency directly opposite to that of the branches; but there are exceptions to both parts of this rule (*fig. 7 ap.*).

The origin of the holes in the thallus of this lichen has been discussed in several papers already. Of these I have been able to see only three, namely, Agardh's original papers,[4] in which he first describes the plant as an alga, and Lutz's.[5] In the last, various papers are cited. After summarizing and criticising the views of his predecessors, Lutz proceeds to describe his own experiments and conclusions. He worked only with dried herbarium material, and had never seen the plants in nature. His observations were, therefore, necessarily limited, and his results are naturally incomplete. Indeed, the obscurity and uncertainty regarding this lichen are due to the unnatural conditions under which small quantities of it have been examined, from the time when Agardh acquired some of it, supposed it to be an alga, and named it "*Chlorodictyon foliosum* (J. Ag. mscr.) Hab. . . . in Hb. J. E. Gray. (sine ulla de origine et loco adnotatione),"[6] until now.

Lutz calls attention to the gelatinous material in which the outer hyphæ are imbedded, and to the fact that, because of this, the outer parts at least will swell when moistened. He cut terminal portions from dry herbarium material, and measured the expansion which took place when water was brought into contact with them. He found that the expansion was from 20 to 43 per cent., and the more rapid the thinner the pieces. All parts, old as well as young, expand on wetting; all parts expand unequally if the water is unequally distributed over them; and if water is applied to only one side or edge of the thallus, or thallus fragment, that side will expand first and most, the transfer of water from part to part being comparatively slow. Such unequal expansions also occur in nature, because raindrops fall first on some parts, then on others, though during a rain-storm of longer duration all parts become uniformly moistened. The unequal wetting and consequent unequal expansions develop strains which tend to pull apart the thallus, the moist, soft parts pulling against and away from the dry, stiff parts in all directions. The majority of the hyphæ run longitudinally, the outer ones more regularly than those within; and the thallus is thin.

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[4] (*a*) *Chlorodictyon.* Öfvers. af K. Vetensk. Akad. Förhandl. no. 5, 1870; and. (*b*) Lund's Univ. Arskr. **9**: 23. 1873.

[5] Ueber die sogenannte Netzbildung bei *Ramalina reticulata* Krplhbr. Ber. d. Deutsch. Bot. Gesellsch. **12**: 7. 1894.

[6] *Ibid. a.* p. 434.

The result of wetting is that the thallus increases somewhat in thickness, more in length, and most (proportionally) in breadth. For example, a thallus branch, which I measured, was

$1\frac{13}{32}$ inches long $\frac{9}{32}$ inch broad	when air dry, - - - - - -	35.7^{mm} 7.1^{mm}
$1\frac{22}{32}$ inches long $\frac{13}{32}$ inch broad	when soaked for 3 minutes in cold water, -	42.8^{mm} 10.3^{mm}

$\frac{9}{32}$ inch=increase in length=7.1^{mm}=20 per cent.
$\frac{4}{32}$ inch=increase in breath=3.2^{mm}=44 per cent.[7]

The most evident reason for this greater proportional expansion in the breadth is that the gelatinous material, on absorbing water, is met by less resistance to swelling outward (transversely) against the air, than longitudinally against other gelatinous matter and the hyphæ towards the tip and the base from the wetted part.

From the unequal expansions, the proportions of which I have roughly measured and indicated in the above table, Lutz concludes that the perforations may readily arise by simple pulling apart of the generally longitudinally running hyphæ, adding that the breaks appear in the weakest parts of the thallus, namely in the thinnest parts, where the "bark" layer is virtually absent and where the spherical gonidia are most abundant (they are nowhere uniformly distributed), for in such places the hyphæ cannot bind them tightly together. This is true, but it is not all the truth. Microscopical examination of living material shows that the hyphæ are not merely in contact with the gonidial cells but are attached to them by haustoria which penetrate the cells,[8] and that the hyphæ bind the gonidia together in fairly coherent masses *except* when the gonidia have divided so rapidly that the young cells are not yet held fast by haustoria, though the mass and even individual cells may be enmeshed by hyphæ. The region of most frequent and most rapid multiplication of gonidia is that near, though not necessarily next to, the tip, and even in fairly old parts, such divisions of gonidial cells occur, and necessarily occur, if in these parts the hyphæ are to be adequately supplied with food-furnishing cells. To some degree in all parts of the lichen thallus, therefore, and most in the younger parts near the tips, there will be masses of young and small gonidial cells not yet held firmly by investing and penetrating hyphæ, and these masses will form the less coherent parts of the thallus, which can be more readily torn through by the unequal and mainly transverse expansions produced by unequal wettings.

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[7] The metric figures in this table are *calculated* from the figures in inches, which were obtained by *measurement.*

But Lutz, though he mentions the peculiar tips of the branches of the thallus of *Ramalina reticulata*, overlooks the part they play in the formation of holes. The tips (*figs. 2, 3, 4, 5*) are narrower than the thallus just behind, and are rolled over. A section of the tip is crozier shaped (*fig. 6*). If a short branch, a few millimeters long, is put convex side down (that is, with the apex pointing upward) on a horizontally placed slide, and a drop of water put on the upper surface of the branch near the apex, the apex will be pushed forward by the longitudinal expansion of the thallus, but the youngest part will expand more, the apex itself will swell like the rest of the thallus in all three directions (in length, breadth, and thickness) and will bend upward slightly and then curve backwards somewhat over the thallus, thus straining the flat young part of the thallus just behind. But if the experiment be modified by placing a similar branch convex side down on a drop of water already on the slide, the apex will curl much more and much more rapidly, and thus the strain on the young parts just behind will be much greater. Because the apex is always narrower than the flat part of the thallus, and because it is always circinately curved, it cannot expand so much as the part behind. The young flat part is furthermore less coherent than either the closely rolled apex or the older flat parts farther back, because of the rapid multiplication of the gonidial cells and the consequently feeble attachment (if any) of the hyphæ to them. The apex then, in folding over, pulls the young flat part on the convex side, thus straining it longitudinally and inducing transverse ruptures in it. At the same time, the thallus is expanding transversely in the same part, but expanding most at a point not immediately behind the apex, for the narrower circinate, and, therefore, thicker apex opposes transverse expansion in the flat thin part closest to it. Precisely where the longitudinal strain is greatest, inducing transverse ruptures in the looser gonidial areas, there the transverse strain is also greatest, inducing longitudinal splits in the same gonidial areas.

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[8] I shall discuss this in detail in a subsequent paper.

Thus we see that it is not simply the expansion, or the unequal expansion, in three directions which produces the holes in the thallus of *Ramalina reticulata*, although this is the main factor in the older parts (where the formation of new holes is less frequent), but it is also the curving and consequent straining longitudinally of the softest and least coherent parts of the thallus, near the tip, by the folding over of the apex, and the concentration, owing to the narrowness and circinate curvature of the apex, of the greatest transverse strain in that zone where the longitudinal strain is also greatest.

Such experiments as those just described can be performed on intact thalli or larger fragments, either in the laboratory or in nature, quite as well as upon small pieces on the stage of the microscope. The dry thallus may not be able to retain the whole of a drop of water, but some of it will be held by the gelatinous outer part; there expansion will take place, and, if enough water has been held, curvature also. The nearer the tip the point is upon which the drop falls, the thinner it will be, the more prompt and the greater will be the expansion, the more pronounced the curvature, the greater the strain, the less coherent the structure of the thallus, the greater the likelihood of ruptures occurring in the weakest areas. Except when rain falls unaccompanied by any wind, and except in fog, the thallus is not likely to be uniformly wetted and in the former case uniform wetting would not be accomplished immediately. So in nature the conditions of expansion and curvature, as demonstrated by experiment, are normally realized.

Lutz says that drying after wetting brings about a change in the shape of the thallus, the length being greater, the breadth less, but the area the same as before the water was supplied; and that these contractions and changes in shape produce new and enlarge already existing holes. If such changes normally took place on drying, holes would result; but they do not take place. Lutz's method of experimentation is probably to blame for his conclusion. He used such small pieces of lichen that his experiments were conducted on the slide, under a magnification of thirty diameters. The moistened gelatinous matter on the surface of the lichen would naturally adhere to the glass somewhat, enough at least to prevent perfect contraction to the original form, and, as his fragments were several times longer than broad, there would be most adherence and least contraction longitudinally, which was what he found. I allowed the fragment which I had used for determining the expansion on wetting, in the experiment above reported, to dry quite free of such adherences by hanging it up. It contracted within five hours to

$1\frac{13}{32}$ inches in length $= 35.7^{\text{mm}}$
and $\frac{10}{32}$ of an inch in breadth $= 7.9^{\text{mm}}$.

that is, to the same length exactly and to within $\frac{1}{32}$ of an inch of the original breadth.

Two more points should be noted in connection with the formation and enlargement of holes; namely, the relative tensile strength of the lichen when dry and when wet, and the part played by growth. I have made tests of which the following may be taken as the average. A piece of thallus with large holes bounded by stout filaments and bands was hung, tip downward, from a hook of small iron wire (not so fine as to cut the lichen quickly. This hook passed through a hole in the mesh and the part above appeared to be of average strength. From a similar hook similarly placed below were suspended weights. The breaking strength of the two strands which held the hooks was 150 grams when dry. The lichen was then soaked for fifteen minutes in cold water and hung up again, after the surface water had been removed. I tried to select for the support of the wire hooks two strands of size and position as nearly as possible the same as before. The strands broke with a weight of 30 grams, 20 per cent. only of the weight carried when dry. The experiment is rude and has evident faults (for instance, the strands are not of uniform strength under like conditions, hence in testing dry the strongest strands may be used, thus leaving absolutely, as well as relatively, weaker ones for testing wet; and the whole thallus had probably been weakened by weighting dry, hence it was weaker when wet than it ordinarily would have been); but it has some value in indicating the quality if not the quantity of difference in tensile strength under the two conditions.

This experiment indicates the longitudinal tensile strength. The transverse tensile strength must be less. Microscopic examination of sections, and unsectioned but cleared fragments of the thallus, shows, as before stated, that the hyphæ run mainly longitudinally in strands, fewer obliquely, almost none exactly transversely. Evidently the transverse tensile strength, both dry and wet, would be less than the longitudinal. But I have shown that the length of a piece of thallus increases about 20 per cent. on wetting, whereas the breadth increases at least twice as much. From these figures we must infer that the transverse tensile strength must be much less when the thallus is wet than when it is dry. What the proportions are is not important.

These experiments and considerations show that, when the lichen thallus is being most strained by expanding and bending, it is also becoming weakest, namely when it is wet.

Growth, whether equal or unequal in different parts, would tend to enlarge those holes already formed. The growth of the longitudinally-running hyphæ, which form the strands bounding or between the holes, would lengthen these strands and cause them to bound larger holes. Unequal growth in young parts where holes had been formed either not all or only in small numbers, would produce strains favoring, if not wholly causing, the formation of holes at the points of greatest weakness. Growth takes place only when and where the lichen is wet and therefore mechanically weak. Growth would be unequal if the distribution of water in the thallus were unequal. That growth is unequal is evident from the fact that only very limited parts of the thallus are flat. The water-supply of different parts of the lichen will frequently be unequal, growth will therefore necessarily be unequal, growth strains will be unequal, the thallus will be most strained in weakest parts, these weakest parts will therefore be made still weaker. The growth of the new gonidial cells formed by the division of old ones will weaken and strain the part of the thallus where they are. If the growth of hyphæ and gonidia does not accomplish the formation of holes in the weakest parts, it at least facilitates it, and the strains produced afterwards by wetting, expanding, and curving, will do so. But growth is notoriously slow in lichens, and hence it cannot be an important factor in the formation of the holes as compared with the purely mechanical effects of wetting.

This explanation of the mechanics of hole formation presupposes the peculiar structure and composition of the thallus as a whole and the peculiar structure and mode of growth of the apex. Why the apex is consistently narrower and circinately inrolled, why the gonidia are distributed as they are, these are questions not answered by this mechanical explanation. They remain for further physical and physiological examination.

LELAND STANFORD JUNIOR UNIVERSITY.

A CONTRIBUTION TO THE LIFE HISTORY OF EUPHORBIA COROLLATA.[1]

FLORENCE MAY LYON.

(WITH PLATES XXII–XXIV)

INFLORESCENCE.

THE inflorescence of *Euphorbia corollata* is of the complicated form known as a cymose umbel. From the axils of bracts on the main stem of the inflorescence there arise three to five branches, each terminating in a smaller inflorescence called a *cyathium*, still occasionally referred to as "a flower"[2] (*figs. 12, 13, 14*).

These branches in turn produce bracts with axillary branches and terminal cyathia, and so on through four, five, or rarely six generations of branches (*fig. 14*). As the secondary and tertiary branches of the inflorescence develop, there is a tendency to diminish the lateral members, so that the ultimate branching may become dichasial. Again, all the terminal cyathia on the branches preceding the penultimate may be lacking.

THE CYATHIUM.

The cyathium has every external appearance of a perfect, complete flower (*fig. 12*). The involucre of five white bracts looks like a gamopetalous perianth. At the entrance to the tubular portion are developed five glands, which, together with five delicate outgrowths of the involucre, nearly block the passage. Within this involucre and opposite its component bracts are five groups of staminate flowers. A group commonly consists of three members, and each staminate flower is a single stamen terminal on a pedicel, and distinguishable externally from a stamen only by a slight joint which marks the insertion of filament upon pedicel. In the center of the inflorescence arises the pistillate flower, distinguished also from a pistil by a joint in its axis. It is made up of three carpels forming a trilocular ovary with a single suspended anatropous ovule in each chamber, and a style with three deeply bifid branches. Masses of glandular hairs envelop the base of the pistillate flower, forming a dense screen between it and the staminate flowers. After fertilization the pedicel of the pistillate flower grows with great rapidity, carrying it far out of the involucre (*fig. 12*).

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[1] Contributions from Hull Botanical Laboratory. X.

[2] BAILLON: Histoire des plantes 5: 109. 1874.

ORGANOGENY.

The first trace of the cyathium is a papilla-like outgrowth between two bracts which are themselves in the axil of a larger bract (*fig. 1*, and the bud shown in *fig. 12*). Near the base of this papilla there soon appear five protuberances (*fig. 2*), the forerunners of the involucre. In their axils arise the oldest staminate flowers (*fig. 3* s^1). Simultaneously with these, and shortly before the appearance of the carpels, the three ovules are distinguishable on the outer rim of the papilla (*fig. 3 o*). The three carpels develop independently from the main axis above the oldest staminate flowers, which, at the same time, give off near their bases branches which are the second generation of staminate flowers (*fig. 4*). The carpels grow rapidly, their adjacent edges coalescing and turning inward as they develop, in such a way as to enclose each of the three ovules in a separate compartment (*fig. 7*). A third set of staminate branches spring from the pedicels of the second, and occasionally a fourth from these (*fig. 5*). The notch marking the boundary between filament and pedicel appears when the stamen is nearly mature (*fig. 5* s^1).

A regular perfect flower does not develop thus. Stamens arise acropetally from the flower axis, and not as branches from stamens of a preceding generation, as is evident here from the course of the bundles. The resemblance of a single cyathium to a reduced inflorescence of exactly the same type as the whole cluster (*fig. 14*) is very marked, as may be seen by comparing the fibro-vascular bundles in the dichasial group of staminate flowers in *fig. 5*, with the diagram of the main inflorescence in *fig. 14*. If in the latter, the terminal flowers after the first be suppressed, and the second, third, and fourth branches produce but one branch each, the resulting arrangement would be strictly comparable to that which obtains in the cyathium of *E. corollata*. The tendency of the terminal flower of the cyathium (*i. e.*, the pistillate) to disappear is marked, about one in ten having either a very rudimentary flower as in *fig. 15*, or no trace of one at all. The cyathium of *E. corollata* may be interpreted then as a much reduced inflorescence, made up of certain ultimate branches of a more complex inflorescence, possibly of simple flowers, which is still undergoing reduction.

MEGASPORANGIUM AND MEGASPORES.

The very young ovule stands nearly erect in the lower part of the loculus (*fig. 6*). It develops in such a manner as to become recurved, the loculus becoming more roomy by an intercalary growth of the base of the carpel and the funiculus. The stalk of the ovule, too, becomes elongated, until finally the ovule is suspended and anatropous, with the micropyle close to the funiculus and the raphe running along the inner edge (*figs. 6–11*). The development of the two integuments may be traced by the figures; the inner one appears first on the outer surface of the ovule, and is closely followed by the second, which soon surpasses it (*figs. 7–11*).

The embryo sac develops by the usual stages. A single hypodermal cell is differentiated from its neighbors and cuts off a primary wall cell (tapetum) (*figs. 18–20*). This is followed by a division of the primary sporogenous cell into an axial row of four mother cells, the lowermost of which develops into the sac (*figs. 21–24*). The cells of the nucellus, and possibly of the epidermis near the upper end of the sac, divide with great rapidity, producing a long, slender neck and leaving the sac deeply situated (*figs. 22, 23, 25, 26*).

A mass of active, glandular hairs develops on the placenta above the funiculus. Some of these apply themselves to the inner face of the nucellar neck, which bends toward them as it continues to lengthen (*figs. 11, 26, 52*). By the time the embryo sac is in the eight-celled stage, the tip of the neck has reached the narrow apex of the loculus and is closely appressed to the placental tissue (*fig. 52*). The integuments envelop it, and the outer one becomes attached to the placental tissue in such a manner as to enclose the neck completely. An axial row of cells, larger and of looser structure than the surrounding tissue, is developed through the entire length of the neck (*figs. 26, 52*). These connect with a line of glandular cells that leads through the placental tissue to the stigmatic surface of the style (*fig. 52*). The pollen tube thus has a definite and direct passage to the modified cells in the neck, which break down as it approaches.

The extremely long synergids hang from the upper end of the sac with the oosphere suspended between their free tips (*figs. 27–29*) in the direct path of the pollen tube which passes between them (*fig. 30*). The fusion of the polar nuclei takes place near the egg in either the longitudinal or the tranverse axis of the sac (*figs. 27, 28*). The antipodals are very ephemeral, having been seen but once in several hundred slides. The endosperm nucleus does not divide before the egg is fertilized (*fig. 30 end. n.*). Immediately after the entrance of the pollen tube, the neck of the nucellus and the glandular hairs disappear, and the outer integument closes the mouth of the micropyle with a little cap that develops from its inner edge. At the time of fertilization, when the embryo sac has encroached on the nucellus to the base of the ovule, the tissue in this region divides into a mass of small but comparatively thick-walled cells, forming a floor upon which the sac rests (*fig. 11*).

MICROSPORANGIUM.

When the stamen is but a small swelling (*fig. 3* s^1) there appear in four distinct regions, approximately equidistant from one another, plates of hypodermal archesporial cells (*figs. 30, 31, 32*). All of these divide once to form axial rows (*fig. 32*). These rows are radially placed, forming a mass of cells shaped like a truncated cone with its apex inward. Of the cells forming the inner layer, only a limited number, and, as a general thing, but one becomes the ancestor of the spore mother cells (*fig. 33*). The outer layer divides at once into two layers, thrusting the primary potential sporogenous cells down where there is even less room to divide (*fig. 33*). Among these one cell soon may be distinguished by superior size and different stain as the forerunner of the spore mother cells referred to above. The hypodermal layer of cells divides by periclinal walls into two layers (*fig. 34*). The tapetum is developed from the wall, and is frequently differentiated some time before the mother-cell stage (*fig. 34*). The development of the spore mother cells (*fig. 36*) and a clearly defined synapsis stage (*fig. 37*), with the usual division into tetrads, follow (*figs. 38–40*). In one preparation the mother cells had divided into fives and sixes instead of tetrads (*figs. 42–46.*) Nothing was observed to suggest how they were formed. It may be noted from the figures, however, that unlike the cases of Hemerocallis described by Juel,[3] the spores are of the same size.

The ordinary sequence of events leads to the development of the pollen grain, which is a spherical body with three deep grooves running from pole to pole. A large vegetative and a smaller lenticular generative nucleus were seen in the pollen grain and in the tube, but no trace of a division of the generative cell preceding tube formation (*figs. 48–51*). The pollen tube, with one generative cell and the vegetative nucleus, were frequently seen in cross sections of the peculiar nucellar neck, which led to the inference that either the generative cell may not divide at all, or if it does, one of the male cells disappears before the pollen tube enters the micropyle. The actual fusion of the gametes was not observed.

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[3] Cytologische Studien aus dem Bonner Botanischen Institut. 51–72. 1897.

SUMMARY.

The "flower" of *Euphorbia corollata* is an inflorescence of the same type as the general inflorescence or cluster of which it is a unit. This is shown not only by the rudimentary development of perianths about the "pistil" and "stamens," but more emphatically by the fact that the order in which the organs develop is not that of a flower, but of an inflorescence.

2. This inflorescence, or cyathium, shows a marked tendency to become reduced still further by the disappearance of its carpellate flower in the approximate ratio of one to ten.

3. The development of the ovule is marked by an elaborate outgrowth of the nucellus into a long neck whose direction of growth is guided by placental hairs which exert an attractive influence, causing it to bend toward them and in this way making a complete connection between the stigmatic cells and the embryo sac for the passage of the pollen tube.

4. Ovules appear before there is any trace of carpel, being clearly of cauline origin.

5. The synergids are remarkably long, and the antipodals so ephemeral that only once were they discovered in several hundred preparations. This suggests the possibility of their having been overlooked in certain instances where they have been reported as absent.

6. As a rule but a single cell becomes the ancestor of all the spore mother cells in a single pollen sac.

7. The tapetum may be clearly differentiated, at least one division preceding the pollen mother cells. It is developed from the wall.

8. Abnormal cases of five and six spores instead of tetrads were observed.

9. The synapsis stage was found with perfect regularity.

10. Evidence was obtained suggesting that the generative cell may not divide.

THE UNIVERSITY OF CHICAGO.

EXPLANATION OF PLATES.

PLATE XXII.

The figures, with the exception of *figs. 15, 16, 17*, are diagrams. In all others, unless otherwise indicated, the optical combination was Reichert ocular 4 and Bausch and Lomb $\frac{1}{12}$ oil immersion. The drawings have been reduced to three-eighths of their original size as drawn with the Zeiss camera.

FIG. 1. Young bud of a cyathium of *E. corollata* with no differentiation of flowers.

FIG. 2. Same older, showing developing involucre (*i*) in axils of bracts (*b*). Vascular bundles in this and succeeding figures indicated by dotted lines.

FIG. 3. Still more advanced stage, in which five staminate flowers (s^1) have developed in the axils of the involucral leaves; the free margin of the papilla is slightly elevated into three ovules. Two cyathia of a younger generation are shown in the axils of the bracts (*b*).

FIG. 4. Ovules more advanced (*o*). Carpels have appeared at the bases of the ovules (*c*). A second group of staminate flowers, each of which is a branch from the staminate flower just above it (s^2). Involucre enclosing all flowers.

FIG. 5. Carpels about to unite with axis of flower. A mature staminate flower (s^1) with a notch marking the insertion of the filament upon the pedicel. Staminate flowers of the second, third, and fourth generations showing the dichasial arrangement. The gland (*g*) and ingrowing flap are developing on the inner margin of the involucre, while the five free petal-like parts are turning outward. In this, as in the preceding figures, *b* indicates the two green leaves which envelop the cyathium.

FIGS. 6–10 show the shifting position of the ovule from nearly erect to an anatropous suspended position. The two integuments are shown in each figure, the inner appearing the earlier.

FIG. 11. The nearly mature ovule with the nucellar neck bent toward the glandular hairs on the placenta. The shape of the embryo sac and the pad of thick walled small cells at the base of the nucellus are shown diagrammatically.

FIG. 12. Habit sketch of a cyathium after fertilization of ovules. A younger cyathium is developing in the axil of one of the green bracts that enveloped the older cyathium during its growth.

FIG. 13. Ground plan of cyathium.

FIG. 14. Diagram of main inflorescence, a cymose umbel.

FIG. 15. Portion of an abnormal cyathium in which no pistillate flower has developed.

FIGS. 16, 17. Abnormal staminate flowers; one with accessory anthers developed at the notch (*fig. 16*), the other with a cup-like perianth in the same situation (*fig. 17*).

PLATE XXIII.

FIGS. 18–20. Young megasporangia, showing first division of primary archesporial cell into tapetal and primary sporogenous cells, In *fig. 19* the primary tapetal has in turn divided, as has also the adjacent epidermal cell.

FIG. 21. Next stage in mother cell row.

FIGS. 22–24. One-celled embryo sac with remnant of mother cell row above and marked development of nucellar tissue in this region.

FIG. 25. Two-celled embryo sac; nucellus dividing further, and epidermis forming two layers of cells.

FIG. 26. Four-celled embryo sac; several glandular hairs with their conspicuous nuclei applying themselves to "neck;" differentiation of axial row of cells into so-called "channel cells;" portions of the two integuments shown in outline.

FIG. 27. Eight-celled embryo sac; the elongated synergids with the egg between their free tips lie in the upper part of the narrow sac; the polar nuclei fusing; the ephemeral antipodals.

FIG. 28. Polar nuclei fusing in transverse axis.

FIG. 29. The upper end of the sac in the eight-celled stage showing the relative positions of the synergids, the egg, and the endosperm nucleus to the "channel."

FIG. 30. Fertilization stage; pollen tube with male gamete passing between the disintegrating synergids toward egg lying beneath; the endosperm nucleus has not divided.

PLATE XXIV.

FIG. 30*a*. Young microsporangium showing one cell of archesporial plate differentiated.

FIG. 31. More advanced stage.

FIG. 32. Microsporangium showing two of the four plates of archesporial cells; one undergoing division.

FIG. 33. Still later stage, where the hypodermal layer seen at the right of *fig. 32* has divided, thrusting the layer under it down toward the center of the anther; only one cell in each of the conelike masses gives evidence of becoming the ancestor of the spore mother cells.

FIG. 34. A stage in which the tapetum is differentiated; about twelve sporogenous cells, ten of which show in the section.

FIG. 35. Later stage; tapetum not yet differentiated.

FIG. 36. Spore mother cell stage; tapetum developed.

FIG. 37. Synapsis stage.

FIG. 38. Stages following synapsis.

FIG. 39. Division into tetrads.

FIGS. 40, 41. Formation of microspores.

FIGS. 42–46. Irregular division into five and six spores instead of tetrads.

FIGS. 47–50. Development of pollen grains and division of nucleus into a larger vegetative and a smaller lenticular generative nucleus.

FIG. 52. Diagram of pistil showing relation of stigmatic surface, path of pollen through placenta, and connection with channel in neck of nucellus leading to embryo sac.

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c
i
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o
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s³
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LYON on EUPHORBIA.

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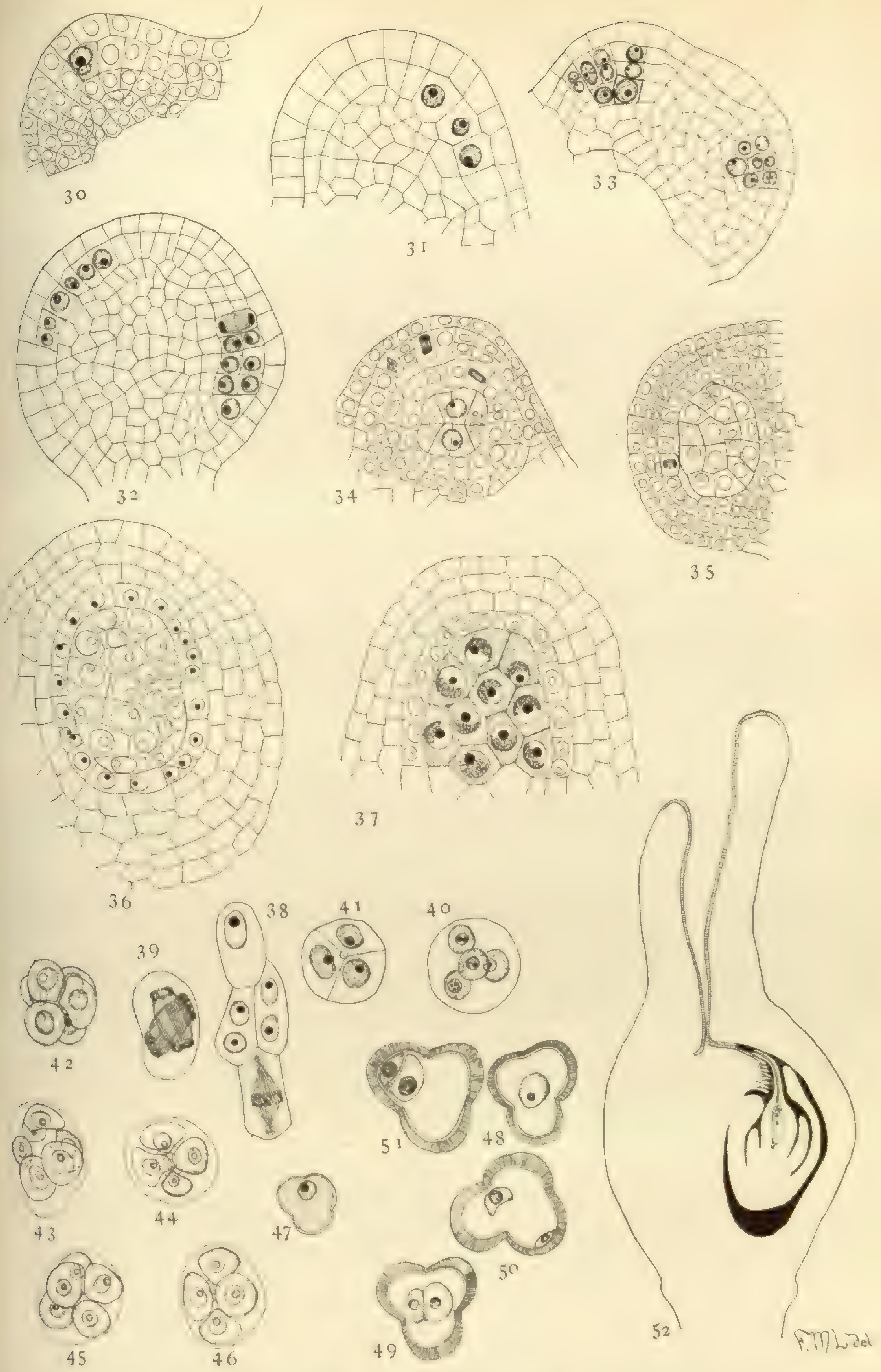
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LYON on EUPHORBIA.

A BIOLOGICAL NOTE ON THE SIZE OF EVERGREEN NEEDLES.

EDWIN BINGHAM COPELAND.

THE profound influence which a prevalence of favorable or unfavorable weather in any season exerts upon the growth of stems is a matter of universal observation. Inadequate nutrition of the plant may be expected, and in general will be found to find expression in a more or less stunted development of both internodes and leaves; though in individual cases this parallel influence may be concealed by the different response of the two members to variations in light or moisture, acting as stimuli.

The best specific instance, with which I am acquainted in literature, of the effect of imperfect nutrition upon the growth of leaves, is in a brief note by Reinke,[1] who measured, on young trees of a number of species of Pinus and Abies, the length of needles formed (*a*) the year before the trees were transplanted, (*b*) the year when they were transplanted, and (*c*) the second year thereafter. In consequence of injury to the roots during transplanting, the needles formed during that year were materially shorter than those of preceding or following seasons.

Gregor Kraus[2] observed that the length of the needles varies from year to year[3] under the influence of "Boden und Klima," and mentions several instances: as one, in which the size of the leaves of deciduous trees is affected by the different illumination of different parts of the tree; and another in which, the strength of the tree going largely to the fruit, fruiting apple trees bore smaller leaves than sterile ones. From a prevalent occurrence of shorter needles on the youngest year's growth, and from direct measurements, Kraus advanced the doctrine of a further growth in length of the needles of Pinus after the first year; which Meissner[4] and S. Honda,[5] from a mass of negative results deny. From his numerous measurements Meissner recognized the variations from year to year, and seems to regard this observation as one of his most important results.[6] But though he mentions in one place (*ibid.* 217, 1897) the effect of a dry summer in the growth of short needles, he introduces without explanation the fact that the variations on the main stem and on its branches are parallel, and expressly contradicts Kraus' statement that there is a relation between the length of the stem and that of the needle. As illustrating and emphasizing the influence of the conditions of vegetation on the development of leaves, the following notes may be of interest, although their most conspicuous feature is that already chronicled by Reinke.

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[1] Berichte d. d. bot. Gesells. **2**: 376.

[2] Abhandl. d. naturf. Gesells. zu Halle **16**: 363. 1886.

[3] *Ibid.* 365. "Die absolute Länge der Nadeln eines Triebes hängt mit der Kräftigkeit des Jahrestriebes überhaupt zusammen. In günstigen Jahren werden bekanntlich sehr lange und kräftige, in ungünstigen viel kleinere und schwächere Triebe gebildet, und die Kräftigkeit oder Schwächlichkeit gilt nicht bloss für die Achsen, sondern auch für die Blätter."

In the spring of 1896 a considerable number of evergreens were transplanted to the campus of Indiana University. The most of these are still living, and except in the case of *Pinus Strobus* still bear leaves three, four, or more years old. I have measured needles from two or more plants of each species and in the appended tables present a fair average case of each. In every instance the needles formed during 1896 are conspicuously shorter than those of 1895 or 1897, giving the young trees a very odd appearance. The per cent. of shortening varies of course in the different plants, according to the injury they sustained in being moved.[7] The greatest decrease present in the tables is 74.6 per cent. on *Pinus Austriaca*. A still greater effect

[4] Bot. Zeit. **52**^{1}: 55. 1894, and **55**^{1}: 203. 1897.

[5] Not seen. Ref. Bot. Centralb. **67**: 25.

[6] Loc. cit. 217. 1897. "Die Nadeln nehmen von Jahr zu Jahr an Länge zu, dann ab, dann wieder zu, etc."

[7] REINKE, loc. cit. *Abies brachyphylla*, transplanted without injury to the roots, showed no change in the needles.

was observed in many instances; in fact it not infrequently occurred that *no* leaves were formed during 1896, the apical bud having remained almost dormant through that year, and grown again normally in 1897. Since it was the weakness of the trees as a whole that found expression in the stunted needles, it was bound *a priori* to show itself alike on all stems and branches, of whatever order, and I have thought it worth while to show this only in table IV. It was equally to be expected that such profound variations in the strength of the plants would affect the stems and the leaves alike, and as all the tables show, this was found to be true. In some cases the effect was most marked in the leaves, in others, notably Taxus, in the stems.

The growth of the stem in thickness was likewise uniformly checked. Thus in all cases the annual ring formed in 1896 was appreciably thinner than that of other years; which indeed was to be expected, as merely an unusually dry season is able to leave its record in a thinner ring. The leaves formed in 1896 were not only shorter but less in diameter as well, as is shown by the area of their cross sections. The leaves measured were among the largest of each year's growth. The measurements were made by drawing the outlines with a camera lucida on paper of uniform thickness and cutting out and weighing the sketches.

On trees set out in 1897 (table VII) it was of course that year in which the needles were dwarfed in length and diameter, and the annual ring remained thin.

While the shorter stem-segments of the season following transplanting bore also shorter leaves, they were much more densely beset by them; so that in most of the tables the total number of needles formed is found to have been greatest in that year.[8] I forbear to offer any hypothetical explanation of this interesting phenomenon. The number of needles compensates the plant for their lack of size, sometimes furnishing an even greater surface of leaf than is borne on the normal year's growth of stem.

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[8] MEISSNER sometimes confuses the internode with the year's growth in length. The internodes are much more conspicuously shortened after transplanting than is even the year's growth, since their number is commonly increased.

As clearly noted by Kraus, and emphasized almost humorously by Meissner, the length of the needles formed during different years on *uninjured* trees varies considerably with the prevailing climatic conditions. This appears undisturbed only in table VIII, which is introduced rather to show what might have been expected during these years, of the smaller trees, if their development had not been interrupted. There is absolutely no reason for suspecting an automatic periodicity in the length of the needles. These constant yearly fluctuations can only be regarded as less conspicuous symptoms of the same general state of matters which when exaggerated finds expression in the various phases of dwarfing of transplanted trees. In the latter case, that of transplanted trees, if we seek to apply the old "law of the minimums" it is probably safe to say (overlooking the possibility that this is in part an instance of "correlation") that the inability to get a proper supply of water is the factor which places the limit on growth. This must often be true, too, when the variations depend on the "Klima;" and the summer of 1897 (see table VIII) was indeed a destructively dry one in Bloomington. But the early part of the same season was unusually cold, and what part of the failure of the needles to reach their average length was due to the drought, and what to the late spring, cannot be said. To analyze the complex of conditions comprehended under a season's "weather" is not immediately practicable.

Even in the relatively simple case of transplanted trees Reinke probably went astray when he attempted any further analysis of the cause of dwarfing. He satisfied himself, in some way, that enough water was absorbed through the periderm of the old roots to cover the loss by transpiration, and concluded therefore that the normal development of the leaves is in part dependent upon the root pressure. Very probably it does depend upon the amount of water present within the plant; but before one ascribes a share in it to actual root pressure, it should be shown that there is some pressure under normal conditions, present throughout the season of active growth; or that the length of the needles varies — as the root pressure probably does, if present at all — with the distance from the ground.

Since the variation from year to year, like the disturbances following transplanting, depends upon the general condition of the tree, it is self-evident that they will be the same on the main axis and on all its branches.

The most casual observation shows that in this climate the needles or leaves formed during any year are at first very short, afterward longer, and at the end of the season again short. In measuring the needles to find the average length for each year, it was immediately apparent that the progression in the length of the needles was surprisingly uniform. The first lines of figures in the individual tables show this almost as forcibly as plotting the curves would do. Each measurement is the average of ten successive needles, except in the instance of *Pinus Austriaca*, in which ten pairs of needles were taken. The figures at the beginning of each line represent the lowest needles on the year's growth of stem. Ten leaves taken each time is too many to show the curve in any detail when the year's growth bears as few leaves altogether as in the instances of Tsuga and Taxus; but on branches so conspicuously dorsiventral the leaves borne on the under side are so much longer than those above that taking a smaller number each time yields too broken a curve. The series of needles still clinging to stems more than three years old is usually quite incomplete, but except in one or two cases I have been unable to see that the shorter needles were cast off before the longer.[9]

The numbers representing the needle lengths advance each year from the spring minimum to a maximum, usually near the middle of the yearly growth in length, and then decrease to the fall minimum, which is usually lower than the first one. In many of the tables there is no break in the rise or fall, and what irregularities do appear in others are insignificant. The curves plotted from these data are at least as regular as can be obtained from actual measurement during the season. And while the causal connection of the two curves is not actually demonstrated, I do not doubt that both represent the same thing, the different vital activity at different seasons, as the plant gradually arouses from its winter rest in spring and sinks into it in late summer and fall. The tree keeps its own record of its annual period of activity in the length of its needles; and we do very well if the record we construct from continuous measurement of the rapidity of growth is equally legible.

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[9] S. HONDA, loc. cit.: On species of Pinus he found the smallest leaves formed latest each year, and seldom clinging more than one year to the stem.

The cause of this regular annual variation is the same complex, constituting its environment, which in some years stimulates the growth of longer, in others, of shorter leaves all summer; with perhaps a larger part played by the temperature, and less by the moisture, in the production of the rhythmic than of the irregular variations. How little the regular annual period depends upon present conditions, and how largely it is hereditary, in response to the climatic conditions of the plant's ancestors, cannot now be said, but it probably depends very much upon the species. No conclusions can be drawn from the Araucarias[10] in a local greenhouse, which show occasional zones of short leaves, corresponding possibly to periods of rest, for the greenhouse is only an attempt to reproduce their natural climate.

TABLES.

Except where otherwise specified, the measurements are made from lateral branches of the first order. In each table the average needle-length in successive zones, of ten needles each, from below upward, illustrating the regular yearly rise and fall in needle-length, is given first. Then follow the average *needle-length* of each year, the area of the *cross section* of a large needle, the length of the year's growth of *stem* (the same on which the measured needles grew), and the thickness of the annual *rings*. The needles are measured in millimeters.

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[10] DE BARY: Comp. Anat. 513. Annual rings are not always regularly present in the wood of Araucaria.

I. *Pinus Austriaca* Hors.

1895. 104.0, 106.4, 106.2, 104.2, 101.0 (11 pairs).

1896. 25.9, 27.7, 29.1, 29.6, 29.4, 28.5, 29.0, 29.1, 28.5, 28.3, 27.1, 25.2, 24.6, 23.9, 23.3, 23.1, 22.7, 22.2 (12 pairs).

1897. 107.1, 113.9, 112.8, 114.0, 114.0, 105.6 (12 pairs).

	Needle-length	Cross-section	Stem	Rings
1895.	104.36^{mm}	$0.864^{mm\ sq}$	22^{cm}	35 tracheides.
1896.	26.51	0.523	7.8	22 "
1897.	111.23	1.188	8.2	75 "

Though the response of the plant to its injury was more marked in this tree during 1896 than in any of the other trees represented by tables, its recovery by the next year was unusually complete, only the stem's growth in length seeming still to suffer.

II. *Pinus Strobus* L.

There were too few needles for their sequence to be instructive. In the growth of 1897 they were borne uniformly in fives; in that of 1896, often in threes or fours. Those of 1895 were all fallen.

	Needle-length	Cross section	Stem	Ring
1896.	59.57^{mm}	$0.227^{mm\ sq}$		0.189^{mm}
1897.	83.39	0.296		0.307

III. *Picea alba* Link. (*P. Canadensis* (Mill.) B. S. P.). Seven-year old tree.

1895. 9.0, 11.7, 13.9, 14.0, 14.8, 15.4, 15.5, 15.5, 15.4, 15.5, 15.1, 15.0, 14.4, 13.3, 12.3 (6 needles).

1896. 4.3, 5.1, 5.7, 6.2, 6.6, 7.1, 7.4, 7.8, 8.0, 8.0, 8.1, 8.4, 8.3, 8.3, 8.3, 8.2, 8.2, 8.0, 7.9, 7.7, 7.5, 7.4, 7.1, 6.8, 6.3, 5.7 (12 needles).

1897. 10.7, 13.5, 16.6, 17.6, 18.4, 19.5, 19.7, 20.2, 20.2, 20.4, 20.4, 20.3, 19.8, 19.6, 19.5, 19.1, 18.2, 17.8, 16.8, 14.9, 14.4, 12.6, 7.8.

	Needle-length	Cross section	Stem	Ring
1895.	14.05^{mm}	$0.418^{mm\ sq}$	15.3^{cm}	0.430^{mm}
1896.	7.25	0.262	6.7	0.185
1897.	17.30	0.600	14.0	0.298

IV. *Picea pungens* Engelm. About six years old.

1894. 13.9, 15.5, 15.6, 15.6, 15.8, 15.9, 15.4, 15.0, 14.8, 14.6, 14.3 (12 needles).

1895. 13.0, 15.1, 16.9, 17.0, 17.4, 17.5, 17.7, 17.4, 17.2, 17.1, 16.8, 16.5, 16.0, 15.6, 14.4, 12.9 (11 needles).

1896. 5.6, 7.5, 8.2, 8.5, 9.3, 9.7, 9.9, 10.0, 10.1, 10.2, 10.1, 10.3, 10.3, 10.4, 10.4, 10.5, 10.5, 10.0, 8.1 (7 needles).

1897. 11.7, 13.0, 13.9, 14.7, 15.0, 15.0, 14.9, 14.8, 14.7, 14.4, 13.8, 13.1, 12.4, 10.2.

	Needle-length	Cross section	Stem	Ring
1894.	15.13^{mm}		7.1^{cm}	
1895.	16.16	$0.847^{mm\ sq}$	8.2	0.262^{mm}
1896.	9.45	0.477	6.3	0.148
1897.	13.69	0.688	6.5	0.536

Branch of second order.

1895. 11.0, 12.9, 13.6, 14.0, 14.0, 14.3, 14.2, 14.1, 14.1, 13.6, 13.3, 13.0, 11.6 (14 needles).

1896. 4.7, 6.8, 7.9, 8.6, 8.5, 8.4, 7.6, 6.5, 4.9.

1897. 11.3, 12.6, 13.3, 13.8, 13.8, 13.7, 13.4, 13.1, 12.7, 11.9, 9.5 (8 needles).

	Needle-length	Stem
1895.	13.36^{mm}	6.2^{cm}
1896.	7.1	2.7
1897.	12.65	4.4

One year is not always sufficient for recovery from the injury of transplanting. Trees as young as these, if left to themselves, produce every year longer leaves than the year before. So the length in 1897 would naturally exceed that in 1895.

V. *Picea nigra* Link (*P. Mariana* (Mill.) B. S. P.).

1895. 7.7, 8.5, 9.6, 10.2, 10.7, 11.0, 11.4, 11.7, 11.9, 11.8, 11.8, 11.8, 11.8, 11.7, 11.5, 11.4, 11.1, 10.6, 10.4, 10.0.

1896. 3.4, 5.1, 6.3, 6.5, 6.8, 6.9, 7.0, 7.0, 7.0, 7.0, 7.1, 7.0, 7.1, 7.2, 7.0, 7.0.

1897. 7.6, 10.4, 11.5, 12.8, 13.3, 13.6, 13.6, 13.8, 13.7, 13.8, 13.8, 13.7, 13.7 13.4, 13.2, 12.9, 12.8, 12.6, 12.3, 12.2, 11.8, 8.4.

	Needle-length	Cross section	Stem
1895.	10.83^{mm}	$0.415^{mm\ sq}$	9.7^{cm}
1896.	6.59	0.222	4.3
1897.	12.50	0.409	8.1

The annual ring of 1896 was thinner than the others.

VI. *Picea excelsa* Link. Six-year old tree, transplanted in 1896.

1895. 14.4, 15.5, 16.1, 16.1, 16.5, 15.7, 16.1, 15.8, 15.8, 15.4, 15.6, 14.7, 14.3, 13.4, 13.2, 12.8 (12 needles).

1896. 8.2, 9.9, 10.9, 11.1, 11.3, 11.5, 11.6, 11.4, 11.3, 11.3, 11.2, 11.1, 11.0, 10.9, 10.7, 10.5, 10.5, 10.4, 10.0, 9.8 (11 needles).

1897. 15.8, 17.7, 19.3, 19.5, 19.7, 20.1, 20.1, 19.6, 19.7, 19.4, 18.8, 18.6, 15.8, 12.0, 10.6 (7 needles).

	Needle-length	Cross section	Stem	Ring
1895.	15.09^{mm}	$0.483^{\text{mm sq}}$	8.3^{cm}	0.325^{mm}
1896.	10.73	0.307	6.4	0.127
1897.	17.78	0.543	9.9	0.245

VII. *Picea excelsa* Link. Seven-year old tree, transplanted in 1897.

1895. 16.9, 19.1, 20.4, 21.5, 21.5, 21.2, 21.4, 21.4. 20.7, 19.1, 14.2 (5 needles).

1896. 12.8, 14.5, 15.8, 16.8, 16.9, 16.8, 16.8, 16.2, 15.6, 15.2, 14.6, 12.2 (14 needles).

1897. 6.2, 8.3, 9.0, 9.3, 9.6, 9.8, 9.8, 9.8, 9.6, 9.8, 9.6, 9.5, 9.5, 9.6, 9.1, 9.2, 8.9, 8.9, 8.7, 8.3, 8.0, 8.0, 7.8, 7.4, 6.7 (6 needles).

	Needle-length	Cross section	Stem	Ring
1895.	19.77^{mm}	$0.494^{\text{mm sq}}$	11.1^{cm}	0.300^{mm}
1896.	15.35	0.419	12.8	0.240
1897.	8.82	0.191	4.6	0.144

VIII. *Picea excelsa* Link. Tree about twenty-five years old. Lateral branch of second order.

1894. 16.5, 18.4, 19.6, 20.0, 20.3, 19.9, 20.4, 20.6, 21.0, 21.1, 20.8, 20.6, 19.6, 19.9, 18.5, 18·3, 17.9 (7 needles).

1895. 18.2, 21.8, 22.8, 22.4, 23.1, 24.0, 23.1, 23.1, 23.0, 21.7, 21.2, 19.7 (12 needles).

1896. 19.0, 20.1, 20.7, 21.1, 22.1, 22.3, 22.8, 22.3, 22.6, 22.2, 21.8, 21.8, 21.8, 21.1, 16.7 (13 needles).

1897. 15.5, 17.7, 18.6, 18.7, 18.6, 18.0, 18.2, 18.2, 18.0, 17.3, 17.6, 16.8, 16.0, 15.2, 15.2, 16.0, 12.9.

	Needle-length	Stem
1894.	19.61^{mm}	9.8^{cm}
1895.	22.01	10.0
1896.	21.23	10.2
1897.	16.97	11.0

IX. *Abies balsamea* (Linn.) Mill.

1895. 10.5, 13.1, 14.6, 16.2, 16.5, 15.9, 14.6, 13.9, 13.6, 12.3, 10.4.

1896. 6.5, 7.6, 8.5, 8.7, 9.0, 9.1, 9.2, 9.2, 8.9, 8.7, 8.9, 8.4, 8.1, 8.1, 7.5, 7.3, 6.8, 6.2, 5.7, 4.4 (8 leaves).

1897. 13.2, 15.6, 16.8, 17.2, 17.6, 16.8, 16.4, 15.7, 14.6, 14.0, 13.1, 9.5 (8 leaves).

	Needle-length	Cross section	Stem	Ring
1895.	13.78^{mm}	0.307$^{mm\ sq}$	10.9^{cm}	0.206^{mm}
1896.	7.84	0.354	4.4	0.07
1897.	15.04	0.477	6.3	0.115

X. *Tsuga Canadensis* (Linn.) Carr.

1896. 7.5, 8.1, 7.6, 7.3.

1897. 8.1, 9.2, 8.3, 8.1, 6.9, 5.9 (13 leaves).

	Leaf length	Stem
1895.	10.00^{mm}	9.2^{cm}
1896.	7.62	2.5
1897.	7.75	4.1

Many of the small dorsal leaves do not cling to the stem more than one year; hence the figures for 1895 and 1896 are too large in proportion to those for 1897.

XI. *Taxus baccata* L.

1895. 13.0, 16.9, 16.3, 12.7, 11.0, 9.9.

1896. 7.9, 8.4, 5.7 (6 leaves).

1897. 13.9, 17.2, 17.3, 14.9, 7.5 (4 leaves).

	Leaf length	Cross-section	Stem	Ring
1895.	13.3^{mm}	1.318$^{mm\ sq}$	8.3^{cm}	39 tracheids
1896.	7.58	0.773	2.1	6 "
1897.	15.07	1.045	8.2	20 "

Indiana University,
Bloomington, Ind.

SOME REASONS WHY THE ROCHESTER NOMENCLATURE CANNOT BE REGARDED AS A CONSISTENT OR STABLE SYSTEM.

B. L. Robinson.

Since the vivacious discussions of 1890 to 1895 comparatively little has been published in America upon botanical nomenclature. While this lull in the conflict between opposing and often too sharply expressed opinions is grateful to all concerned, the difficult and intricate nomenclature question is as far from settlement as ever. The subject may seem trite and tiresome, but the present divergent practices in naming plants are not only a source of great annoyance but offer a serious impediment to the successful advance of classification. The gravity of the whole issue is, therefore, so great as to justify every renewed effort toward a better general understanding of the subject, since this alone can lead to a final and satisfactory settlement.

Some years ago a number of our American colleagues, with conscientious efforts and praiseworthy intentions, devised and offered to the world a nomenclature reform, hoping that it would gain ground and soon meet with general approval and adoption. This, however, has not been the case, nor has its ill success been due to prejudice. While among its opponents there may have been some, it is true, who, with little knowledge of the subject, opposed the system merely because it involved changes of familiar names, there were others who objected to the Rochester nomenclature because it seemed to have certain inherent defects of a nature to preclude ultimate success. During the years which have passed since the Rochester and Madison meetings little effort has been made to correct these defects and the energy of the reformers has been largely devoted to establishing their code by putting it into immediate use in their publications and herbarium work. The fact that this has been done in disregard of the opinions and expressed wishes of a very large number of their colleagues does not concern us here, except as showing an unfortunate over-confidence on the part of the reformers. What they should realize, however, is that no number of monographs or floras, published in accordance with the Rochester code, will establish a single principle or a single name, which does not appeal to future botanists as reasonable. Surely those who have themselves discarded hundreds of names which had stood unchallenged for nearly a century should not feel that they are establishing their system merely by putting it into use. The only way it can be established is by making it so reasonable and consistent that it will command general respect and approbation.

Readily accepting the now generally admitted fact that 1753 is the most desirable date of departure, the writer can see only two logical methods of codifying botanical nomenclature. According to the first of these modes, priority both of time and place must be unrestricted from the date of starting. Each plant must bear *its earliest designation*, and each name must be used *only in its earliest signification.* Such a system would involve a hitherto unprecedented change but is both conceivable and logical. The other method, while also recognizing the great value of priority in determining the proper names of plants, would seek to limit this principle by such qualifications as would be necessary to retain as great a part as possible of the current nomenclature. In the first or absolute system no exceptions can be permitted, usage may not be taken into account, and in fact nomenclature must be torn down to the point where it can be rebuilt with regularity and symmetry. The language of systematic botany must, in such a system, start almost afresh and follow unswervingly certain theoretical principles. In the other system, principles must also be sought out and followed, but here, like the rules of grammar, they should be based upon usage and derive their guiding power by stating, generalizing, and correlating usage and not by defying it. Either system to be effective requires a fairly general agreement of botanists. It is not my purpose here to discuss the relative merits of the absolute and usage systems, for that has already been done *ad nauseam.* I merely wish to show that the Rochester nomenclature corresponds to neither of these systems; that it falls between them; and that while claiming to rest upon a firm basis of priority, it derives many of its principal names from usage and in defiance of a consistent priority.

Within the last few years two kinds of priority have been recognized, that of time of publication and that of relative position in a given work. The latter, "priority of place," is as definite and almost as necessary to an absolute system of reform as the more generally recognized priority of time. Both have been acknowledged principles in the Rochester reform, but the reformers in their application of the "priority of place" have been neither thorough nor consistent. While they have felt it necessary to discard many well-established names on account of this principle, they have failed to apply it when determining which of several species is to be regarded as the type of a genus. By way of illustration we may consider the Linnæan genus Erysimum, which, according to the theory of the Rochester code, dates from its treatment in the first edition of the *Species Plantarum.* Now in this work the generic name (unaccompanied by generic character) is followed by four well-known species, namely, *E. officinale* L. (*Sisymbrium officinale* Scop.), *E. Barbarea* L. (*Barbarea vulgaris* R. Br.), *E. Alliaria* L. (*Alliaria officinalis* Andrz.), and *E. cheiranthoides* L. It will be observed that these species are now relegated to four different genera, but strangely enough our reformers, while professing to follow priority as the "fundamental principle" of nomenclature, have selected not the first but the last species of the Linnæan genus to retain the name Erysimum. In other words, they have here abandoned the much-extolled principle of priority and have adopted one of usage. They have taken *Erysimum cheiranthoides* as the true type of the genus, not because it was the first species to bear that name, but because it was the species which had been so treated by subsequent usage. Nor is Erysimum an isolated instance of this kind. The same departure from a strict priority has been made in the case of Sisymbrium, Erigeron, Poa, Senecio, Brassica, and in fact many other important genera.

Now I would not be taken as saying that usage is not a very excellent guide in such matters, but would merely emphasize the fact that if the Rochester nomenclature, in last analysis, really rests upon usage and not upon priority, it loses at once that absolute and decisive character which has been represented as its chief advantage. If we are not to have a consistent application of priority, why overthrow hundreds of established names to accomplish a reform ? If priority is to be modified at all, why not restrain it effectively by some such excellent provision as the fifty-year limit of the Berlin botanists ? Let us have either a nomenclature of consistent principles or one of maximum immediate convenience. As I have said, the Rochester nomenclature appears to be neither. It overthrows too much and fails to establish its new structure upon a logical basis.

I am quite aware that the American ornithologists have stopped in their application of priority at essentially the same point as the Rochester and Madison reformers. The ornithologists' nomenclature, however, possesses the advantage that their code clearly recognizes and defines this departure from its usual principles. The botanical code, on the other hand, wholly neglects to state any such exceptions, and accordingly the usage of the Rochester reformers is to this extent inconsistent with their own code. The exception in the case of the ornithologists has been accomplished merely by general agreement. Of course, if such agreement can be obtained, any system of nomenclature whatever, whether consistent or inconsistent, can be made serviceable. But no system which is not in itself logical is likely to stand the test of time.

It cannot be denied that to take any species other than the first as the type of a genus involves a grave inconsistency with the other principles of the reform.

The much advocated principle of "once a synonym always a synonym,", for instance, states that a name once applied in one sense may not be used subsequently in any other, and this directly affects the case in hand; for to return to the example of Erysimum, the first species of this genus was a Sisymbrium. In other words Erysimum was first employed to designate what we now call Sisymbrium. As we read down the 660th page of the *Species Plantarum* and arrive at the last line in the description of *E. officinale*, we have reached a point where the genus Erysimum has already been published. The needful generic name has been coupled with a definitely characterized and well-known species. If it is not a published genus when we have reached this point, why is any monotypic genus in the *Species Plantarum* to be so regarded? But Erysimum, thus established by the publication of its first species, applies only to what we now call Sisymbrium, and any transfer of the generic name to another genus, is not only opposed to "priority of place" but contrary to the principle of "once a synonym always a synonym," which expressly forbids such a change in the use of a name. The fact that Linnæus himself, further down the same page, published certain other species, which he considered congeneric, or that Erysimum was by later authors differently applied, should have to the mind of the consistent advocate of priority no weight whatever. In this connection I recall the words of Professor Britton:[1]

> I accepted Tissa rather than Buda for the simple reason that it stands first on the page in Adanson's *Familles*. That is priority, I am sure. The fact that Dumortier named some species under Budah as, to me, nothing to do with the case.

In the *Species Plantarum*, as I have above implied, there are many other important genera of like composite character, and interpreted by the reformers with similar disregard of their own principles. Thus the first Sisymbrium was a Nasturtium, and for those who would follow consistently the principle of priority of place, this should stand as the type of a genus Sisymbrium, which must embrace all our present species of Nasturtium, and not be made, as by the reformers, the type of a subsequently published genus, Roripa.

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[1] Jour. of Bot. 19: 265.

It is needless to multiply such examples. Cases in point are many, so numerous, in fact, that the reformers, having gone thus far in the quest of priority, have suddenly been appalled by the amount of change necessary for further advance, and have, accordingly, with no word of explanation, abandoned the pursuit of the principle. But this is stopping the reform not at the goal to which its accepted principles lead, but arbitrarily, and just where it happens to be convenient, surely a disappointing outcome for such an ambitious and widely heralded revision.

This question regarding the type species of a composite genus is not new. It was well discussed by Mr. O. F. Cook[2] in 1895, when he urged, upon the basis of his studies in the Myxomycetes, that the only satisfactory solution was the uniform acceptance of the first species as the generic type. A subject so important to the Rochester reform should certainly have received the prompt attention of the Nomenclature Committee, but far from taking any definite or satisfactory action which could be a guide to others, the members themselves, as their divergent practices clearly show, have been quite unable to agree upon this point. The majority, it is true, still use Erysimum, Sisymbrium, Erigeron, etc., in their conventional meaning, but one member has boldly faced the issue and refuses longer to accept Erysimum in its old sense, since it is clear that its first species was a Sisymbrium. All our American species of Erysimum are accordingly transferred by him to Cheiranthus. This change is carried one step further in a recent American flora,[3] where we find that not only our Erysimums have gone to Cheiranthus, but Sisymbrium is called Erysimum. As each generic change of this sort implies the ultimate formation of many new binomial combinations, the end of this felicitous settlement of our nomenclature question is not yet in sight.

When questioned as to the uniform acceptance of the first species of a genus as to its type, advocates of the Rochester reform have replied that such a course, while logical, would require *too* great change. It would appear then that the Rochester code is a clever device to bring us stability by causing *a great deal* of change, but not *too much* change. In his recent comments upon the Berlin rules,[4] Professor Britton propounds the momentous question : Who is to say whether *Elvasia elvasioides* involves tautology ? It does not occur to him to ask : Who, in the American reform, is to make the refined distinction between *much* change and *more* change ? Yet the two questions in their relative importance forcibly suggest a Berlin mote and a Rochester beam.

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[2] Bull. Torr. Bot. Club **22**: 433.

[3] HOWELL, Fl. N. W. Am. **1**: 38–56.

Besides this matter of the selection of the generic type, various other questions, relative to their nomenclature, seem as yet unsettled by the reformers. What, it may be asked, is the status of a generic synonym in the first edition of the *Species Plantarum ?* Can it be neglected as a "pre-Linnæan" name ? Certainly not, for it appears in print subsequently to the beginning of 1753, the date from which priority is reckoned. These generic synonyms, it may be argued, are not properly described, but for that matter the accepted genera of the same work are not described at all. Both, however, are clearly defined by the species. Now under *Psoralea Dalea* L., the name Dalea is used not solely as a specific name, but, a line or so below, as a generic synonym. In other words, even in "Linnæan" times, the first generic name applied to a Dalea was Dalea. Why then do our reformers feel it necessary to change fifty or more species of Dalea to the subsequently published genus Parosela of Cavanilles ? Nor is this by any means the only instance in which generic synonyms in the *Species Plantarum* are likely to cause trouble. The name Pedicularis, for example, as it first appears on page 602, does not represent the genus to which it is now applied, but is a clear synonym of *Bartsia coccinea*, or as it is now called *Castilleia coccinea*. But, having once been applied to a Castilleia, how, without violence to the principle of "once a synonym always a synonym," can it be later used for a subsequently published plant or group of plants ? Such cases are far too numerous to be disregarded, and a consistent or scholarly code, starting from the *Species Plantarum*, should certainly contain a definite statement as to the Linnæan synonyms. The subject cannot be wholly neglected, for both radical and more conservative botanists have, on certain occasions, taken up names which had first appeared as synonyms, and used them to displace others of subsequent but more regular publication. Is such a practice justifiable in some cases and not in others ?

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[4] Bull. Torr. Bot. Club **24** : 419.

While the object of the present article has been to deal rather with the principles than the details of the Rochester nomenclature, a specific instance may be cited to show that even where their principles may be perfectly clear, the reformers do not always live up to them. Of all the changes suggested by the Rochester reform, none has been more unfortunate than the transfer of Stellaria to Alsine. It involves not merely much specific change but leads to exceptional confusion from the circumstance that there is another large and nearly related genus Alsine, which the European botanists generally recognize and show no tendency to abandon. However, from the standpoint of the reformer, this is due to no fault of the Rochester movement, but merely to the perversity of those benighted individuals who as yet fail to accept the light it sheds. So, waiving for the moment all points relative to the justice and expediency of adopting Alsine for the greater part of Stellaria, I wish merely to defend certain residual rights of the latter genus. It is a long established fact in the common law of nomenclature that if a part of a genus is taken away, the rest must still bear the same name. Now the Stellaria of Linnæus contained two distinct generic elements, Stellaria and Cerastium, for the latter element is represented by *Stellaria cerastioides* L. (*Cerastium trigynum* Vill.; *C. cerastioides* Britton, Mem. Torr. Club **5** : 150, Britton & Brown, Ill. Fl. **2** : 28). The only reason why the reformers transfer our Stellarias to the Linnæan Alsine (a miserable generic failure, made up of *Stellaria media* and a Spergularia) is that Alsine appears on an earlier page of the *Species Plantarum* than Stellaria. But Stellaria has exactly the same sort of priority over Cerastium, and if only a part of Stellaria goes to Alsine, the rest (its other generic element), namely *Stellaria cerastioides* L., must in all justice be retained to stand for Stellaria. Its arbitrary transference, as in the *Illustrated Flora*, to the subsequently published genus Cerastium, is out of the question in any system where "priority of publication is the fundamental principle of nomenclature." But if *Stellaria cerastioides*, according to priority of place, represents the valid part of Stellaria, all the numerous Cerastiums must be rechristened under Stellaria, unless the reformers find it possible to reexamine *Stellaria cerastioides* and decide that it is, after all, an Alsine, a course of procedure which would not greatly strengthen any system.

The facts here enumerated seem fully to justify the conclusion that the Rochester reform, notwithstanding the conscientious endeavors of its advocates, fails to offer a definite or final solution of the nomenclature question. It is perfectly evident that its application of priority, far from being consistent and universal, is subject to certain indefinite and unwritten restrictions, upon which even the reformers themselves cannot agree. The theory of an unrestricted priority from 1753 is most seductive, but it is now clear to many of its former advocates that, while causing much needless change, it secures in the end no greater definiteness nor finality than a priority limited, let us say by the fifty-year clause. Uniformity of practice can only be secured by agreement in any case, and while the fifty-year limit may well give an excellent basis for such agreement, unrestricted priority cannot yet be consistently interpreted by its most zealous advocates.

As former efforts to present in a clear light certain defects in the Rochester nomenclature have called forth prompt and in some cases wholly irrelevant criticism, it seems necessary to say, in conclusion, that the questions here raised regarding Erysimum, Sisymbrium, Nasturtium, Erigeron, Stellaria, Cerastium, etc., are definite difficulties, and as such cannot be satisfactorily answered, to an intelligent public by an unwarrantable accusation of personality nor by vague panegyrics upon priority in general.

GRAY HERBARIUM.

BRIEFER ARTICLES.

NOTES ON THE BOTANY OF THE SOUTHEASTERN STATES. III.

CRATÆGUS MACRACANTHA Lodd., Loudon, Arb. Brit. **2** : 819. 1854. [ed. 2.]—In the valley of the Swannanoa river, near Biltmore, North Carolina, this species has been located recently. The finding of this thorn in the mountains of western North Carolina reveals the existence of not less than thirteen distinct varieties of the genus in this part of the state. While it has been considered that "the headquarters of the genus Cratægus" are in eastern Texas and western Louisiana,[1] the state of North Carolina has at least sixteen species within its borders.

Cratægus macracantha in North Carolina is usually a much-branched shrub, but occasionally attains arborescent proportions. It blossoms two or three weeks later than *C. coccinea* L. and a few days before the small-fruited form of *C. tomentosa* L., referred to in my second paper, and to which variety it is evidently more closely related than to the scarlet thorn. The flowers are produced in broad, leafy cymes, and are much smaller and more numerous than in *C. coccinea*; the leaves, which are borne on stouter and shorter petioles, are narrowed or cuneate at the base, prominently veined and of rather firmer substance, and the fruit at maturity is succulent and smaller than in the last named species. I have aimed to draw direct comparisons between the long-spined and scarlet thorns to point out the great dissimilarity between the two species, and because the disparity in the descriptions of the former in several text-books of botany is most bewildering. I take pleasure in acknowledging material assistance and many notes concerning this confused genus from my associate, Mr. F. E. Boynton, who has been my almost constant companion for several years in botanical pursuits.

CRATÆGUS ROTUNDIFOLIA (Ehrh.) Borck. in Rœm. Arch. **13** : 87. 1798.—The recognition of this species removes another stumbling block from our consideration of this puzzling, yet intensely interesting, genus. It seems that specimens of the above in herbaria have been generally placed with or referred to *C. coccinea* L., and while it has an aspect similar to that species it may be readily recognized. *C. rotundifolia* is abundantly represented in western North Carolina, growing along the banks of streams and even in the shallow, dry soil of old fields and upland woods. It frequently attains the size of a small tree, some 4–6^{m} high, and blossoms perceptibly later than *C. coccinea*, from which it may be distinguished by the very glandular character of the young shoots, thicker leaves, fewer stamens with usually lighter colored anthers, and the greenish or dull russet-red fruits.

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[1] C. S. SARGENT, Silva **4** : 83. 1892.

CRATÆGUS ELLIPTICA Ait. Hort. Kew. **2**: 168. 1789.—A few miles west of Biltmore, North Carolina, this excellent species is abundantly represented in abandoned fields and in open woodlands standing in company with pine and oak timber. In such situations *C. elliptica* often attains the proportions of a small tree, and the spreading, slightly pendulous or recurved, zig-zag branches and branchlets give a strikingly distinct aspect that serves to distinguish the species readily even in winter. In the time of flowering *C. elliptica* is from ten days to three weeks earlier than *C. flava* Ait., which is not uncommon in the region, and, besides, differs from that species by its smaller flowers, larger fruit, broader, thicker, and more glossy leaves, and the pubescence covering the young shoots and foliage.

POPULUS BALSAMIFERA CANDICANS (Ait.) A. Gray, Man. ed. 2. 419. 1856.—Much uncertainty yet surrounds the natural limits of distribution of this fine tree. Professor L. H. Bailey[2] points out its existence in Michigan ; but I fail to find further information of a definite character.

The pistillate, possibly the only known form, is commonly cultivated and sparingly spontaneous at Biltmore, N. C., and other southern points.

POPULUS ALBA L. Sp. Pl. 1034. 1753.—Along many water-courses in the vicinity of Biltmore, N. C., and elsewhere in the south *P. alba* is spontaneous. I have observed only the staminate form, but rapid propagation is effected by broken branches carried by streams and by excessive sprouting from the stoloniferous roots.

[2] BOT. GAZ. **5**: 77 and 91. 1880 ; and Bull. Cornell Univ. **68**: 220. 1894.

Coreopsis longifolia Small, Bull. Torr. Bot. Club **22**: 47. 1895.—Material that closely matches specimens of this species gathered near Jacksonville, Florida, has been collected in Bladen county, North Carolina, June 9, 1896. The plants from North Carolina are plainly of perennial duration and continue to blossom from lateral shoots and possibly by seedlings until autumn.

✓ **Coreopsis helianthoides**, n. sp.—An herb 5–12^{dm} high from a perennial base, growing in the moist, sandy pine barrens of west Florida: stout furrowed stems glabrous and terete, very leafy to near the middle, but almost naked at the divergently-branched summit: radical and lowest cauline leaves 5–12^{cm} long, 2–6^{cm} broad, ovate to ovate-lanceolate, acute, scarious-edged, contracted at the base into long margined petioles and sparingly and inconspicuously hirsute on both surfaces with many-jointed weak hairs; upper cauline few and remote, linear-lanceolate, much reduced in size and passing into mere bracts; petioles dilated and clasping at the insertion by a short sheath: internodes from base to near the middle very short, 1–5^{cm} long: heads 3–18 in number, many-flowered, 3–4^{cm} wide including the rays, 1–1.5^{cm} high: outer involucral scales lanceolate, 5–9^{mm} long, 2–4^{mm} wide; the inner ovate, 8–12^{mm} long, 4–7^{mm} wide, many-nerved; floral scales linear, 5–7^{mm} long, acute: disk flowers dark purple; rays 8, orange-yellow, 3-cleft, the middle segment large and notched at the obtuse apex: achenes oblong, bordered by strong pectinate wings and surmounted by two short hispid awns.

C. helianthoides in general aspect is strikingly like *Helianthus Dowellianus* Curtis, and is related to *C. gladiata* Walt., from which species it differs in its smaller and more numerous heads, very leafy stem, remarkably short internodes, greater length of the outer involucral bracts, larger and acute leaves and much stouter habit.

The type specimens were gathered at Aspalaga, Florida, October, 1897, by Dr. A. W. Chapman, who recognized the form as probably new to science.

Geranium molle L. Sp. Pl. 682. 1753.—This interesting fugitive is thoroughly established in waste grounds at Biltmore, N. C., forming on the surface of the soil mats that are very conspicuous and in fertile situations sufficiently large to cover an area 5^{dm} square. The first seeds ripen in this locality in May, and under favorable conditions a second crop of plants is produced which mature seeds in autumn.

GERANIUM DISSECTUM L. Amœn. Acad. 4 : 282. 1760.—This and the preceding species are not mentioned in text-books at my command as occurring in the southern states. *Geranium dissectum* blossoms at the same time or a little later than *G. Carolinianum* L., when the two species occupy the same area, and matures its first fruit as early as May. Not uncommonly a second crop of plants is produced that blossoms in autumn or late summer. The species is plentiful in waste places and cultivated grounds at Biltmore, North Carolina.

VIOLA TRIPARTITA Ell. Bot. S. C. & Ga. 1 : 320. 1817.—Dr. Small[3] has left little that may profitably be added to strengthen his most just attempt to restore to full standing this much confused and valid species. The affinities of *V. tripartita* are truly with *V. pubescens* Ait. and not with *V. hastata* Michx. Even in simple-leaved forms it is abundantly distinct from the last named species, and not only in the characters set forth in the article above referred to, but by the rootstocks, roots, and as it occurs in the south, by marked differences of environment. The short rootstock and long, coarse roots of *V. tripartita* are conspicuously different from the long horizontal and nearly white, fleshy rootstock and fine, short roots of *V. hastata*, and as found along the mountains and at Biltmore, N. C., *V. tripartita* grows in rather dry and fertile soil on the slopes of the hills or in shallow dales, while *V. hastata* selects a very moist or wet situation in woods and boggy or springy places on the sides of the mountains.

ACHYRANTHES ASPERA OBTUSIFOLIA (Lam.) Griseb. Fl. Brit. W. Ind. 62. 1864.—I have a specimen of this collected by Mr. A. H. Curtiss at Key West, Florida, and recently Dr. Chapman sent to the Herbarium specimens gathered in the streets of Apalachicola, Florida. It is evidently spontaneous at these stations and will doubtless be found at other southern ports.

PANICUM LONGIFOLIUM Torr. Fl. U. S. 149. 1824.—Material gathered near Wilmington, N. C., October 11, 1897, and recently verified by Mr. F. Lamson-Scribner, extends the range of this interesting grass many miles beyond the heretofore recognized limits. In this locality the species inhabits moist savannahs and margins of shallow ponds, growing in scattered tufts over a considerable area.

SYNEDRELLA NODIFLORA (L.) Gærtn. Fruct. 2 : 456. *pl. 171.* 1791. —Dr. Chapman has sent to the Herbarium flowering specimens of this species gathered during the summer of 1897 at Apalachicola, Florida.

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[3] Bull. Torr. Bot. Club 24 : 494. 1897.

Hydrocotyle bonariensis Lam. Encycl. 3: 153. 1788.—Another station in the United States for this fugitive may be added, the species being abundantly and thoroughly established in the vicinity of the ballast dumps at Wilmington, N. C., where it was collected in fruit and flower, July 2, 1897.

Carex laxiculmis Schwein. Ann. Lyc. N. Y. 1: 70. 1824.—On May 13, 1898, in Henderson county, North Carolina, *C. laxiculmis* was found with nearly mature perigynia. I believe this is the first record of the species as belonging to the southern flora.—C. D. Beadle, *Biltmore Herbarium.*

A NEW SPECIES OF APIOS FROM KENTUCKY.

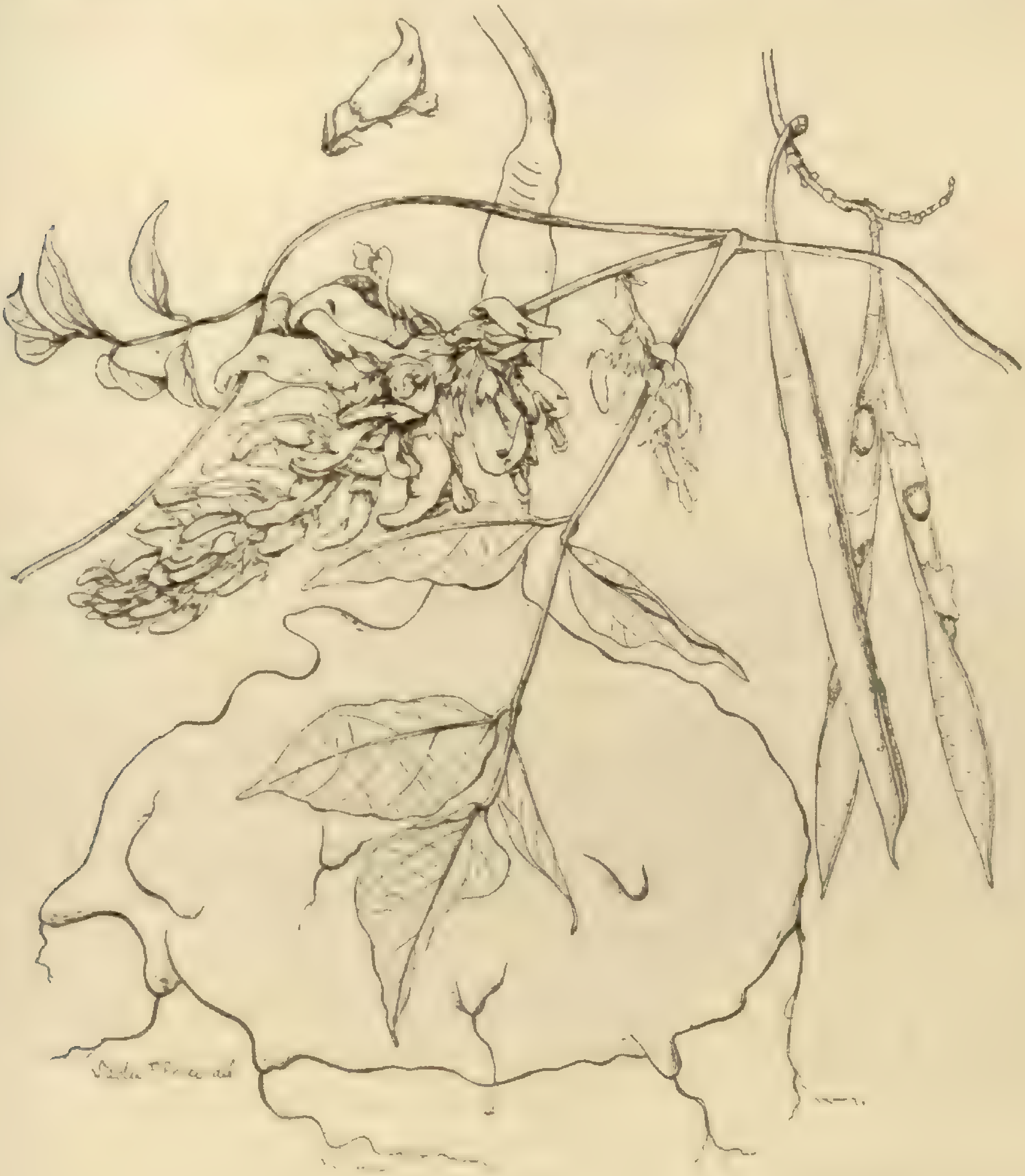
The plant here characterized was discovered some years ago in open woods and thickets near Bowling Green, Kentucky, by Miss Sadie F. Price. After noticing for several seasons its occurrence and peculiar characters, Miss Price, who recognized its genus and believed it a new species, sent it to Professor Charles F. Wheeler of Michigan Agricultural College for further examination. Professor Wheeler, after making dissections and comparisons, concurred in the view that it represented an undescribed Apios, but with undue modesty has declined to characterize it, and Miss Price has recently referred flowering and fruiting specimens, together with careful drawings, to the writer. The species for several reasons possesses more than ordinary interest. It is a second American member of a small but well-known genus. Like its congeners it has farinaceous tuberiform roots, but these attain much more considerable proportions and suggest a possible utility in cultivation. Furthermore, the corolla has a somewhat peculiar form, the standard being provided at the apex with a thick, spongy, knot-like prolongation. Any homologue of this appendage which may exist in the other known species is so rudimentary, if present at all, that its occurrence here seems to warrant the separation of this species as a subgenus. The genus may thus be divided into two subgenera as follows:

Euapios. Standard suborbicular, rounded or retuse at the unthickened summit. Roots (as far as known) fibrous or moniliform-tuberous.

—Including *A. tuberosa* Moench of Atlantic North America, and *A. macrantha* Oliv., *A. carnea* Benth., and *A Fortunei* Maxim. of Asia.

TYLOSEMIUM. Standard produced at the apex into a thickened spongy appendage. Root apparently single, irregularly spheroidal, and of great size.—Name from τύλος, lump, and σημεῖον, vexillum.—A single species, described below, which, notwithstanding the differences indicated, is obviously congeneric with the other species just enumerated under EUÁPIOS.

A. Priceana, n. sp.—Vigorous herbaceous twiner: stem terete, slightly striate, at first covered with a fine reflexed pubescence, but soon nearly glabrate, arising from a large oblate spheroidal root (18^{cm} in diameter): leaves 3–9-foliolate; those of the main stem 24^{cm} long, the ovate or ovate-lanceolate acuminate leaflets sparingly pubescent upon



both surfaces, green and scarcely paler beneath, thin and rather veiny, obtuse or rounded at the base, 4 to 10^{cm} long, half as broad; petiolules hirsutulous; leaves and leaflets of the branches considerably smaller; stipules subulate, pubescent, 6^{mm} long: racemes dense, borne mostly by twos and threes in the axils, those of the main stem often 12 to 15^{cm} long, 50–70-flowered and mostly bearing a single short branch; rameal inflorescences smaller and simple; floral axes thickish; pedicels slender, 5^{mm} long, commonly borne by twos and threes in the axils of ovate caudate-acuminate bracts of somewhat greater length: calyx hemispherical, roseate; the limb obliquely sub-truncate except for the linear-attenuate anterior tooth: petals greenish white tinged especially toward the end with rose-purple or magenta; the vexillum suborbicular, 25^{mm} long, bi-auriculate at the base and bluntly cornute at the apex: wings somewhat shorter, narrowly oblong, a little broadened and rounded at the apex: essential organs of the genus: pods clustered, 12 to 15^{cm} long, 1^{cm} broad, acuminate at the apex, attenuate at the base, about 10-seeded; seeds oblong, olive green, 8^{mm} long, separated in the pod by bi-concave sections of the silvery white pithy endocarp.—Collected in flower and fruit by Miss Sadie F. Price, in rocky woods, Bowling Green, Warren county, southern Kentucky. The type specimens are in the Gray Herbarium.

Miss Price reports that the species often fails to set fruit. She has observed that the flowers are visited by the butterfly *Eudamus tityrus* and by both honey bees and bumble bees, the latter appearing to find the nectaries very difficult of access. The accompanying illustration was drawn from life by Miss Price. It is a pleasure to commemorate in the specific name of this noteworthy plant the work of such a careful observer of the Kentucky flora.

The genus Apios furnishes still another instance of discrepancy between the theory and practice of the Rochester reformers. The generic name Apios, occasionally employed in prelinnæan times, was not used by Linnæus himself, but was revived late in the 18th century. In the meantime, however, Adanson founded his genus Bradlea (*Familles des Plantes* 2 : 324. 1763), which, as he himself states (p. 527), included the first two species of the Linnæan Glycine, namely *G. Apios* (now of the genus Apios) and *G. frutescens* (referred by the reformers to Kraunhia). The former species, cited first by Adanson and resting on a plate of Cornuti, duly mentioned in Adanson's brief description, must be taken as the type of Bradlea. But whether Bradlea stands for its Apios element, or its Wistaria element, it is equally evident that the genus long antedates both *Apios* Moench. and *Kraunhia* Raf., which the reformers keep up for these two elements respectively. Bradlea is not obscure enough to be overlooked, since it is published in Adanson's well-known work from which the reformers have derived so many of their names. It is also duly cited as a synonym of Apios by such works as Pfeiffer's *Nomenclator* and Hooker and Jackson's *Index Kewensis.* It does not appear to be antedated by any homonym, and it is truly puzzling to see why it has been rejected by those who, as they claim, admit no exception to the law of priority. However, its revival at present would be worse than useless, until the value of the fifty-year limit, suggested by the leading German botanists, can be subjected to a careful test. Mention of Bradlea is here made merely to show how little finality the advocates of the Rochester nomenclature have been able to obtain even when dealing with such a well-known genus as Apios.— B. L. Robinson, *Gray Herbarium.*

A CONTRIBUTION TO THE KNOWLEDGE OF THE FLORA OF TUSCOLA COUNTY, MICHIGAN.[1]

During the summer of 1897, while engaged in field work for the Michigan Geological Survey, in that part of Tuscola county which lies adjacent to the eastern shore of Saginaw bay, the writer found what proved from the botanical standpoint an extremely interesting tract of country. This was a narrow, irregular strip of land somewhat back from the bay shore, known locally as the "prairie," which was rarely more than two or three miles in width, frequently much less, and at no very distant time had been a part of the bottom of the bay.

As the geological history of this tract has a clearly defined bearing upon the distribution of the plants which grow upon it, and as it is plainly set forth in easily read records, I will briefly trace it.

The bay off this shore is, and apparently always has been, very shallow. There are areas of the bottom also in which there are broad sand bars. These bars are often of considerable extent, but are still beneath the surface, and are only a few feet higher than the rest of the bottom. After a time one of these bars, in a part of the bay more exposed to the action of waves, is built up until its top is raised above the surface of the water, and the island thus formed being added to by the action of winds, waves and currents, soon builds itself inward at one end nearly or quite to the mainland, forming a spit, and shutting off more or less completely a shallow bay or lagoon, which may be of small or of large extent. After the barrier is raised in front, the inclosed body of water, sooner or later, is surely filled up, and becomes solid land. If the portion of the bay bottom cut off by the "spit" was already filled with sand reefs and bars, with deeper places between them, the process of filling is hastened, for the bars are rapidly added to under the protection of the outer barrier, until their tops are near enough to the surface of the water to get sufficient light to enable seeds of water-plants, which may germinate upon them, to make successful growth. Such plants, once established, become very important factors in hastening the deposit of sediment. The growth of plants undoubtedly is also fostered by the shelter which the spit gives, as in the quiet water behind it the sand and other sedimentary deposits are practically stationary, while in front of it there is constant shifting under wave and current action, so that plants are unable to gain a foothold, where conditions are otherwise favorable.

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[1] Read before the Michigan Academy of Science, March 31, 1898.

Such a spit-formed inlet, under ordinary conditions and with no fluctuations in the level of the bay, in the course of no very great interval of time would become partly filled with a series of islands, more or less sandy, and this phase would give place in due time to a marsh, in which would be strips of sandy or gravelly soil. In the meantime the spit would extend itself in breadth and length, and would form a new boundary for the waters of the bay, upon which the wind would heap sand and débris until a dune-line was formed.

Actually one can read this story over and over again in the region under consideration, its variations being practically limitless and its editions of all sizes.

There are easily found, also, evidences of periods of subsidence of the waters of the bay, of greater or less extent and duration. The past ten or twelve years have witnessed such a period, during which the water-level fell four feet, and even now, when the water is rising again, it is easy to see that the bay will never again occupy all the ground it did before its subsidence, for in bodies of water so shallow as Saginaw bay, a change of level of even a foot makes a very marked change in the shore-line, and competition for place is so keen among plants that every available inch of ground exposed by such a change is soon occupied by them. At least some of this is never given back to the dominion of the waters.

With these facts in mind, let us look over the "prairie" region again, and consider its aspect. The whole section is, as nearly as possible, perfectly flat, the slope to the bay being only four feet to the mile, and treeless, except for thin and straggling lines of trees which are to be seen here and there. The bay is not visible, for there is a line of low tree-covered sand dunes which shuts it off from view, and which has an exaggerated importance seen across the flat expanse of the "prairie." At times this line of dunes looks almost like a line of hills when seen from a distance, yet by actual measurement the highest parts are hardly ten feet above the water level. Besides the lines of trees mentioned there are visible small groves and scattered groups of trees and shrubs, the "islands" in the "prairie." In short, the whole character of the view suggests that about the southern end of Lake Michigan, only here all the surface features are on a much smaller scale.

An inspection of the character of the soil shows three well-defined types distributed in the following manner: (1) sandy ridges, often continuous for considerable distances, varying from a few inches to three or four feet in height above the general level, and rarely more than a few rods in width; (2) broader, more or less extensive tracts of sandy loam; (3) black, vegetable mold which constitutes the greater part of the prairie soil.

The sandy strips are the tree-covered portions, the groves and islands, and, in the light of the history just discussed, they evidently represent dune and sand-spit lines of former days of bay occupation, when the sandy loam tracts were shallows and submerged bars; and the black mold represents the deeper places which have been filled in by the growth and decay of generations of plants under such conditions that their remains were preserved in part. The floras of these three classes of soil are quite distinct and are all interesting, but that of the sandy loam is by far the most peculiar, and is worthy more exhaustive study than the writer was able to give it.

Before discussing it, however, I wish to call attention, briefly, to the plants which characterize the other two classes of soil. The black soil is so largely under cultivation that I was unable to judge much of the higher portions, but in undrained and low places the vegetation, as would be expected, was distinctly limnetic, sedges (especially *Carex* *fusca*, various species of Scirpus, and Eleocharis) and marsh-loving grasses predominating. The sandy ridges were covered with oaks, which with poplars and the species of plants which usually grow with them were to be expected from the character of the soil.

My interest was chiefly centered in the plants of the sandy loam tracts on which there were found growing in greatest profusion the following species, which here are found much to the north and in most cases east of their recorded range in the state, which is quoted from Beal and Wheeler's *Michigan Flora* (1892).

Cratægus Crus-galli L. Found on the border of a tract of sandy loam near the bay. Recorded from Lansing and southward.

Lythrum alatum Pursh, reported from near Detroit and from Kalamazoo, is here very abundant in damp places all over the district.

Ludwigia polycarpa Short & Peter, from near Flint and in St. Clair county, is here common in marshy places.

Silphium terebinthaceum Jacq. Ionia, Macomb county and southward, this plant was exceedingly abundant in places covering large tracts of the poorer soil and grows as far north as Sebewaing, Huron county.

Lacinaria spicata (L.) Kuntze grew with the Silphium and rightly earned its name of blazing star by making the country side brilliant in the middle of August. This plant has been found before as far north as Ionia county and from various other parts of the state to the southward and westward.

Cacalia tuberosa Nutt., reported from the southwestern part of the state, Kalamazoo, etc., was also common here.

Steironema quadriflorum (Sims) A. S. Hitch. was conspicuous and common. This plant has a southern range and seems not to be reported from so far north in the state.

The Asclepiadaceæ were generously represented by the following species:

Asclepias purpurascens L., reported from Ionia and Clinton counties and south.

Asclepias Sullivantii Englm. Not reported in the "Michigan Flora," but found by C. K. Dodge on an island in the St. Clair river, and having a range from Ohio to Kansas and Minnesota. This plant was very abundant on the prairie soil in Akron township, Tuscola county, and probably extends northward into adjacent townships in Huron county.

Acerates floridana (Lam.) A. S. Hitchc. Recorded from but one other station in Michigan, namely South Haven on the Lake Michigan shore, where it was found by Professor L. H. Bailey. It was very abundant in the region under discussion, growing by roadsides, in uncultivated lands and even in some cases encroaching on cultivated ground and becoming a weed.

This list might be extended, but enough species have been enumerated to show that here is a northward and eastward extension of plants, of generally southwestern range, in an entirely unexpected part of the state and separated by considerable distances from the nearest other known stations.

The soil conditions are practically those of the prairie region of the southwestern corner of the state and of the adjacent region of Indiana and Illinois. Climatic conditions are also favorable for the existence of a colony of southern plants here, as the summer isotherms are the same as those of the lower end of Lake Michigan, and even the annual isotherms are but a few degrees lower than those of the southern border of Michigan, and a slightly later spring is practically all the difference in climatic condition of this locality as compared with those to the south.

Hence, since climate and soil are both favorable we have only to account for the introduction of these species into the region to explain the presence of the colony, and to do this satisfactorily, a more careful study of the region to the southwest will have to be made. One notable fact of the occurrence of this colony at this place is that it is entirely to the north of the Saginaw lobe of the great terminal moraine of the ice-sheet. The most northerly ridges of this moraine are at least a dozen miles to the south, and they extend northward into the middle of Huron county well to the east of this region, and while the course of the morainal ridge is such that plants might follow up the shore of Lake Huron and come around the bend in the moraine into the bay region, there are no traces of such a migration in Huron county, where the flora at critical points is entirely different. If the moraine is insurmountable to plants from the south, as has been supposed, then these species must have been carried across it by winds from the southwest, as is possible in case of some of them, since their seeds have a copious pappus or long coma.

Another possible agency of transportation is that of migrating animals, which might easily carry the seeds over the higher elevations, but this seems unlikely in this case, as birds are usually moving to the southward at the season when seeds of plants are most likely to be carried, and the migrations of other animals in the state are too irregular and insignificant to be considered as a factor in the question.

On the other hand, it is also possible that the moraine is not too high to be passed by southern plants, and that stations have been established upon it during favorable periods which were occupied long enough to permit the plants to gain a foothold on the other side, and then the intermediate stations, because of a series of successive unfavorable years, have been destroyed.

In whatever way the matter is finally decided, the fact which is worthy of record at this time is that these plants occur at this point and that they thrive there and are thoroughly at home.

It is probable that similar tracts of land in Bay and Saginaw counties will yield the same species, thus extending their range still farther northward.— Charles A. Davis, *Alma College, Alma, Mich.*

OPEN LETTERS.

AERIAL TUBERS OF SOLANUM.

Editors Botanical Gazette: — W. R. Dodson, in the GAZETTE for January, refers to aerial tubers of *Solanum tuberosum.* It is well known that our varieties of potatoes in cultivation are obtained from selecting seedlings such as suit the cultivator best. From a thousand or two he may get only one, possibly two, three, or more, that he selects for further trial; the rest he abandons. Some eighteen years ago I grew 800 seedling potatoes from berries of several varieties. Among them were several which bore their tubers entirely on the stems above ground, and some produced tubers above and below also. One plant I remember in particular produced about 200 tubers, all at the surface of the ground and a little way above, none covered with the soil. These tubers were mostly the size of the ends of the thumb and fingers of a lady's hand. Of course, the plant was allowed to perish, as of no value. By selecting seedlings of this variable plant we can secure within certain limits anything we dare look for or expect.—W. J. BEAL, *Michigan Agricultural College.*

CURRENT LITERATURE.

MINOR NOTICES.

Messrs. Seymour and Earle[1] have issued a supplement to their series of economic fungi. It consists of forty packets of dried specimens, ten being species of Peronospora and Synchytrium marked *A*, and thirty of various Uredineæ marked *B*. The system of numbering is not explained, and, in fact, the printed matter accompanying the distribution consists only of a folded leaf bearing the title page and contents. Nearly a score of botanists have contributed to this first fascicle. The specimens are excellent, and the publication will doubtless meet with favor.—J. C. A.

NOTES FOR STUDENTS.

Bulletins on weeds are issued by the experiment stations from time to time and add greatly to a knowledge of the habits and distribution of this class of plants. A recent paper by H. Garman (Ky. no. 70, pp. 99–107, *pls. 2*) on "Woolly mullein (*Verbascum phlomoides*) in Kentucky" brings into notice a new roadside and riverside weed. At present it has invaded an area of about fifty square miles in the vicinity of Green river. It is a weed of waste ground rather than of cultivated fields.

"A first Ohio weed manual," by A. D. Selby (Ohio no. 83, pp. 247–400, *figs. 1–71*), forms a thick bulletin and gives information regarding 279 species of plants that should be subdued by the cultivator. Although the species are arranged in the usual systematic sequence, technical diagnoses are not employed. In their stead the striking features that would appeal to the untrained observer are clearly and simply set forth. Besides giving characters which assist in identifying the plant, the seeds are described so that they may be recognized when found in commercial seeds, and what is known regarding the noxious habits of the plants as well as practical methods of subduing them, form an important part of the presentation. The work closes with a tabulation of the distribution of roadside weeds in Ohio, from data furnished by 357 correspondents. The bulletin is an admirable and serviceable contribution to the literature of weeds.

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[1] Seymour, A. B., and Earle, F. S.— Economic fungi supplement, including species of scientific, rather than of economic interest. Nos. *A* 1–10, *B* 1–30. Cambridge, Mass. 1898.

The "Fifth report of Kansas weeds," by A. S. Hitchcock and Geo. L. Clothier (Kans. no. 76, pp. 1–23, *pls. 12*), deals with the vegetative propagation of forty-eight perennials. A dozen plates with well-drawn figures illustrate the subterranean parts and habits of each sort of plant. Tests were made to determine the length of cuttings of roots or rhizomes that would throw out adventitious buds and become established as independent plants. The station is doing good work in issuing its series of weed studies.—J. C. A.

ELENCHUS FUNGORUM NOVORUM for the year 1897 appears in the April number of *Hedwigia*. It is prepared by G. Lindau and P. Sydow, and forms a third similarly published supplement to Saccardo's great *Sylloge Fungorum*. It is interesting to note that the enumeration of species published during 1895 reached the grand total of 1252, for 1896 of 1313, and for 1897 of 1476. This indicates increasing activity in the study of this class of plants. The enumeration does not include lichens and bacteria, but does include the myxomycetes and the myxobacteria.—J. C. A.

THE SPREAD of plant diseases was presented in a lecture before the Massachusetts Horticultural Society by Dr. Erwin F. Smith more than a year ago, but has only recently been printed and distributed. Much stress is laid upon the agency of insects, as they are especially prominent in the spread of pear blight, bacterial wilt of cucurbits, and bacterial brown rot of solanaceous plants, if not exclusively responsible for it. Slugs are known to distribute a number of diseases, including the bacterial brown rot of cabbage. Other methods of distribution are discussed, such as manure, soil, seeds, tubers, etc. A brief statement of preventive measures closes the lecture.—J. C. A.

RECENT BULLETINS from the experiment stations pertaining to vegetable pathology are as follows: "A bacterial disease of sweet corn," by F. C. Stewart (N. Y., no. 130, pp. 423–439, *pl. 4*), deals with a disease heretofore unrecognized. It is a bacterial disease attacking the plant at any stage of its growth, but more often at flowering time, causing the plant to wilt by clogging the fibrovascular bundles of the stem. The germ has been separated and inoculation experiments tried. It does not grow in field corn or pop corn. A review of the "cornstalk disease" of cattle, by A. T. Peters (Neb., no. 52, pp. 51–63), confirms the conclusion of some previous investigators that it is due to a germ entirely distinct from that causing the Burrill disease of corn, which in turn is distinct from the corn disease mentioned above. "A bacterial rot of cabbage and allied plants," by H. L. Russell (Wis., no. 65, pp. 1–39, *figs. 15*), has already received notice in this journal (25 : 67). "The olive knot," by F. T. Bioletti (Calif., no. 120, pp. 1–11, *pls. 3*, *figs. 2* in text), is an account of a disease which is more generally known under the name of tuberculosis of the olive. It was first seen in California in 1893, and is yet known in only one locality. The disease is well described and illustrated. The germ causing it, *Bacillus Oleæ* Arch., was but little studied. Part of a bulletin (Ky., no. 72, pp. 9–23) is given to a report on the prevention of potato scab, by H. Garman. A detailed record of the work in 1896 and 1897 with use of corrosive sublimate shows very favorable results. In 1896 flowers of sulfur was also used, being placed in the drill with the seed tubers, but gave no benefit. "Blight and other plant diseases," by C. S. Crandall (Colo., no. 41, pp. 1–21), includes a good general account of pear blight, both historical and descriptive. Less extended descriptions are given of sun-scald and frost-cracks in fruit trees, leaf blight of strawberry, orange rust and anthracnose of raspberry and blackberry. A finely illustrated and well written bulletin on "Some important pear diseases," by B. M. Duggar (Cornell, no. 145, pp. 592–627, *figs. 15*) describes at length a leaf spot (*Septoria piricola* Desm.) that has heretofore received little attention. It is especially injurious to budded stock of two years or older, and is also prevalent in orchards, attacking only the foliage. Sprayings of Bordeaux mixture were found effective. It was studied microscopically, and also cultivated by the bacteriological method. A less extended account is given of leaf blight (*Entomosporium maculatum* Lev.), which has been confounded with the preceding, scab (*Fusicladium pirinum* Fckl.) and blight (*Bacillus amylovorus* Bur.), with original observations in each case and a brief bibliography. Notable results were obtained in imbedding and sectioning dense stromal tissues. "Rust and leopard spot, two dangerous diseases of asparagus," are described by W. G. Johnson (Md., no. 50, pp. 163–168, *figs. 2*), and their treatment indicated. The second-named disease is caused by an undetermined fungus, the first by *Puccinia Asparagi* DC. "Results with oat smut in 1897," by C. P. Close (N. Y., no. 131, pp. 441–154, also popular edition of 6 pages), show treatment with hot water, formalin, lysol, potassium sulfid, and Ceres powder, to have been effective in the order named, none of them being injurious to the seed. The same investigator has issued a bulletin on "Spraying in 1897 to prevent gooseberry mildew" (N. Y., no. 133, pp. 489–500, also popular edition of 6 pages), showing potassium sulfid to be a remedy far superior to Bordeaux mixture, lysol, or formalin. "Experiments and observations on some diseases of plants," by F. C. Stewart (N. Y., no. 138, pp. 625–644, also popular edition of 6 pages), demonstrates that the popular opinion that green manuring with rye to prevent potato scab, and the use of common salt on carnations to increase growth and prevent rust, have no rational basis. It is further shown that potato stem-blight (cause unknown) is not contagious, and that spraying cucumbers with Bordeaux mixture is especially serviceable against mildew (*Plasmopara Cubensis*). Interesting notes are given on the last named fungus, including a first record of its occurrence on *Cucumis Moschata* Duch. "Prevalent diseases of cucumbers, melons, and tomatoes," by A. D. Selby (Ohio, no. 89, pp.

99–122, 3 pl.), is an account of *Plasmopara Cubensis*, *Colletotrichum lagenarium*, and *Septoria Lycopersici* in Ohio, and efficient means to check them. Brief notes on corn diseases, by L. H. Pammel, and alfalfa leaf spot, by R. Combs (Iowa, no. 36, pp. 854–855, 858–859), are given as abstracts from the annual report of the Iowa Station for 1897.—J. C. A.

AN EXCELLENT illustrated paper on the "Fungous foes of the farmer" has been prepared by Dr. Byron D. Halsted for the Pennsylvania Department of Agriculture, and has been issued as bulletin no. 28 (1897). It is printed and distributed by the state at Harrisburg, Pa.

NEWS.

Professor L. M. Underwood, of Columbia University, sailed for Europe the first part of June.

Professor D. T. MacDougal, of the University of Minnesota, will spend June, July and August in studying the vegetation of the arid regions of Arizona.

Professor Stanley Coulter, of Purdue University, is spending his summer vacation abroad. He will devote some time to study in the laboratory of Professor Dr. Strasburger at Bonn.

The important results of a vacation trip to Mexico in 1896, by which forty-five new species of *Uredineæ* and much other valuable mycologic material was secured, has decided Mr. E. W. D. Holway, of Decorah, Ia., to undertake another similar trip beyond our southern borders during the present summer.

Lloyd's *Photogravures of American Fungi* give two views of *Polyporus Berkeleyi* Fr. for numbers 23 and 24. The specimen grew at the base of a large tree, and was two and a fourth feet across. The photographs and their reproductions are skillfully made, and bring out the characteristic features with great clearness.

The Alabama Biological Survey has sent out a long and interesting list of plants for exchange, including not only flowering plants, but ferns, mosses, liverworts, lichens, and fungi. The specimens are well preserved, ample and authentic, and are largely from Alabama, with some from Colorado. The expedition during the season of 1898 to the mountainous region of southwestern Colorado (not southeastern, as erroneously stated in the February issue), will include several expert collectors, and all classes of plants will be gathered. This region is especially rich in species, and is also interesting for its great ecological diversity. Sets of specimens have already been ordered by the chief herbaria of this country, and by many foreign herbaria. Particular classes of plants, or forms illustrating ecological features, will be furnished at the same rates as for full sets. Inquiries and orders may be sent to C. F. Baker, Auburn, Ala.

GENERAL INDEX.

The most important classified entries will be found under Contributors, Diseases, Journals, Necrology, Personals, Reviews, and Societies. Names of new species are printed in **bold-face type**; synonyms in *Italics*.

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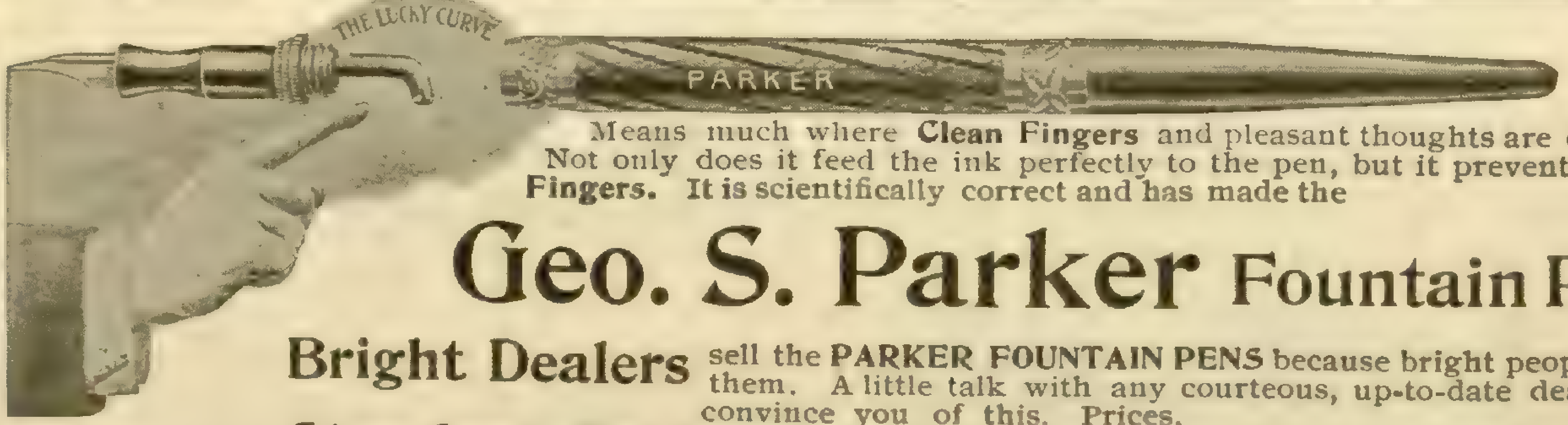

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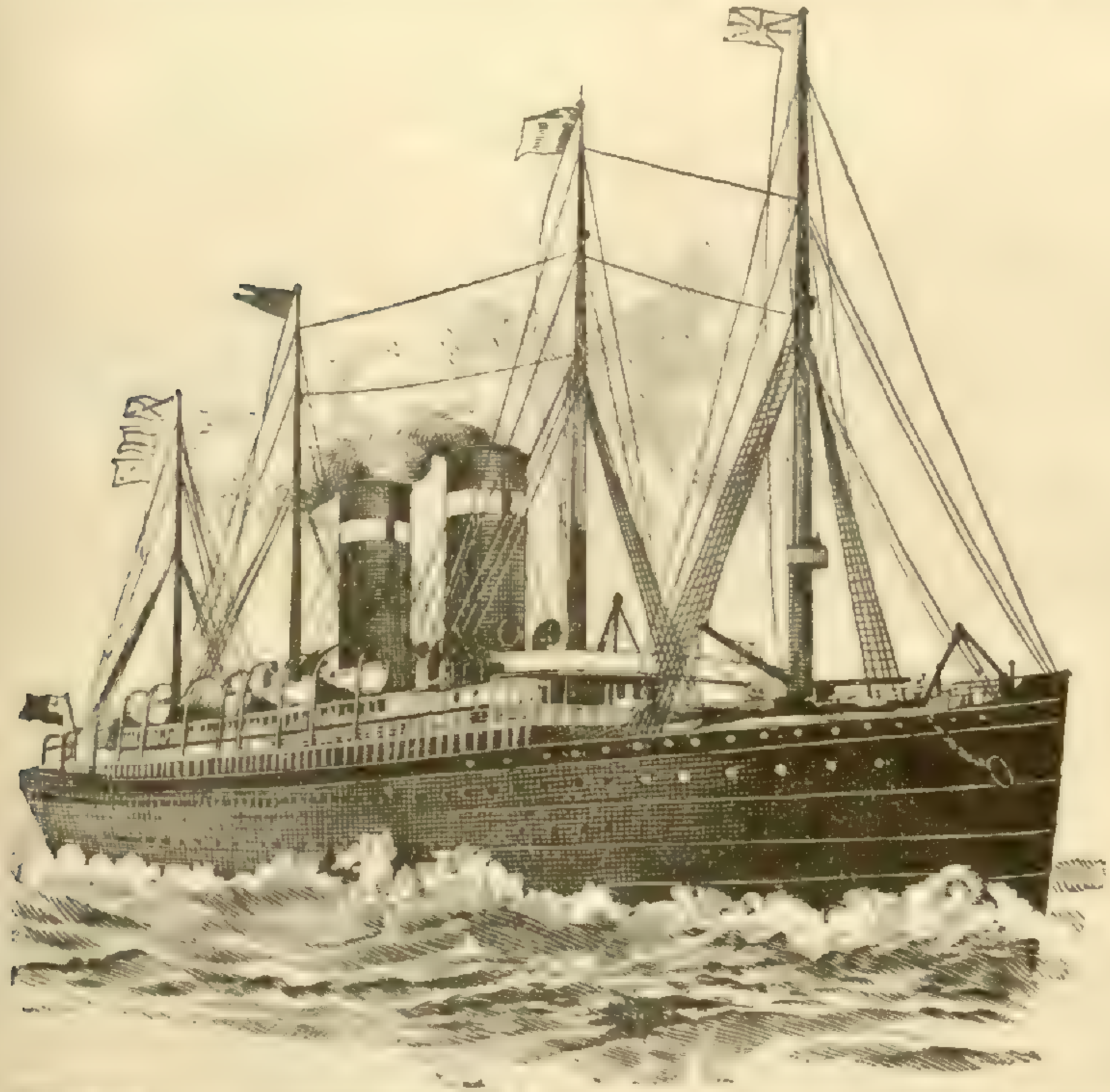

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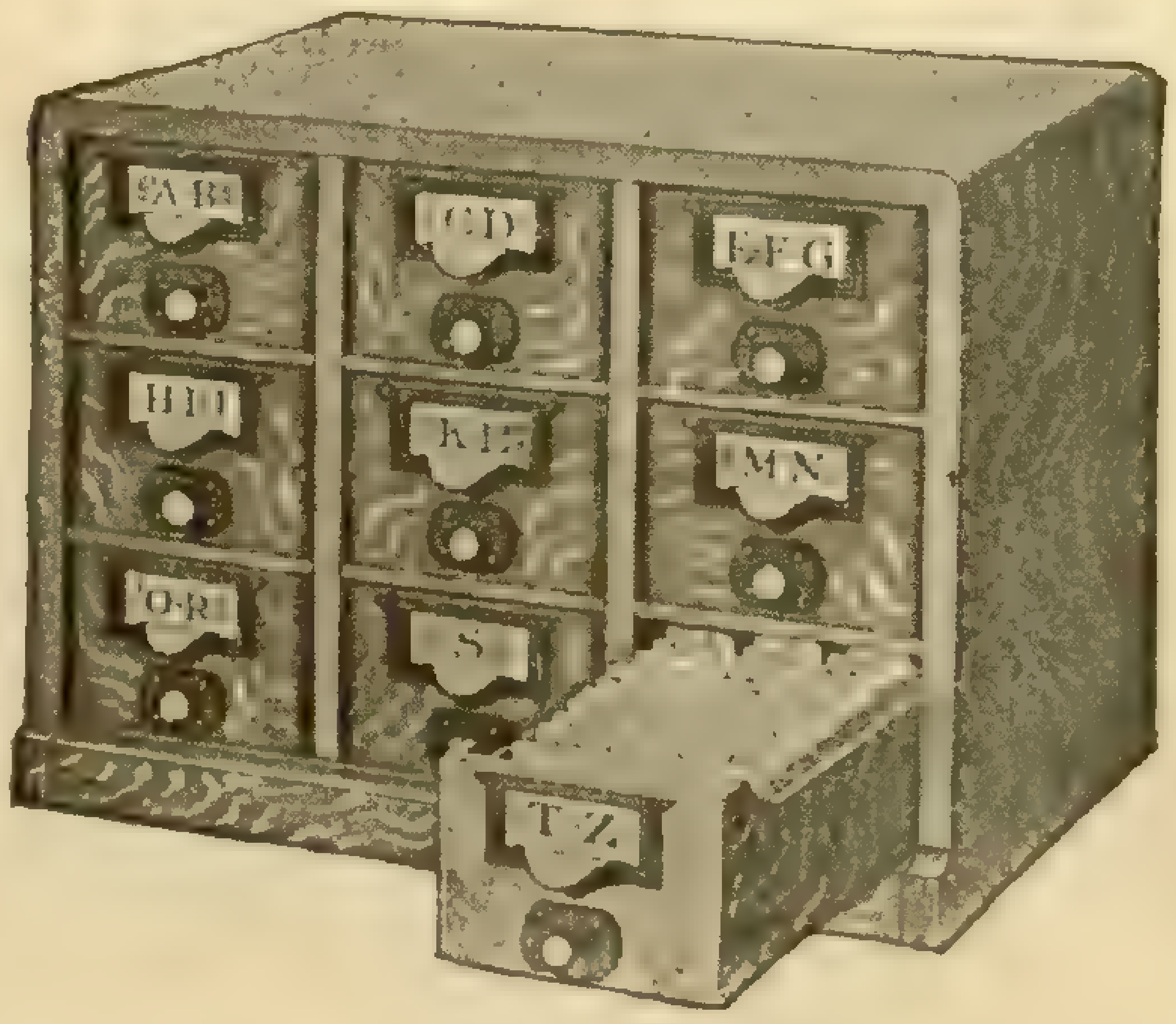

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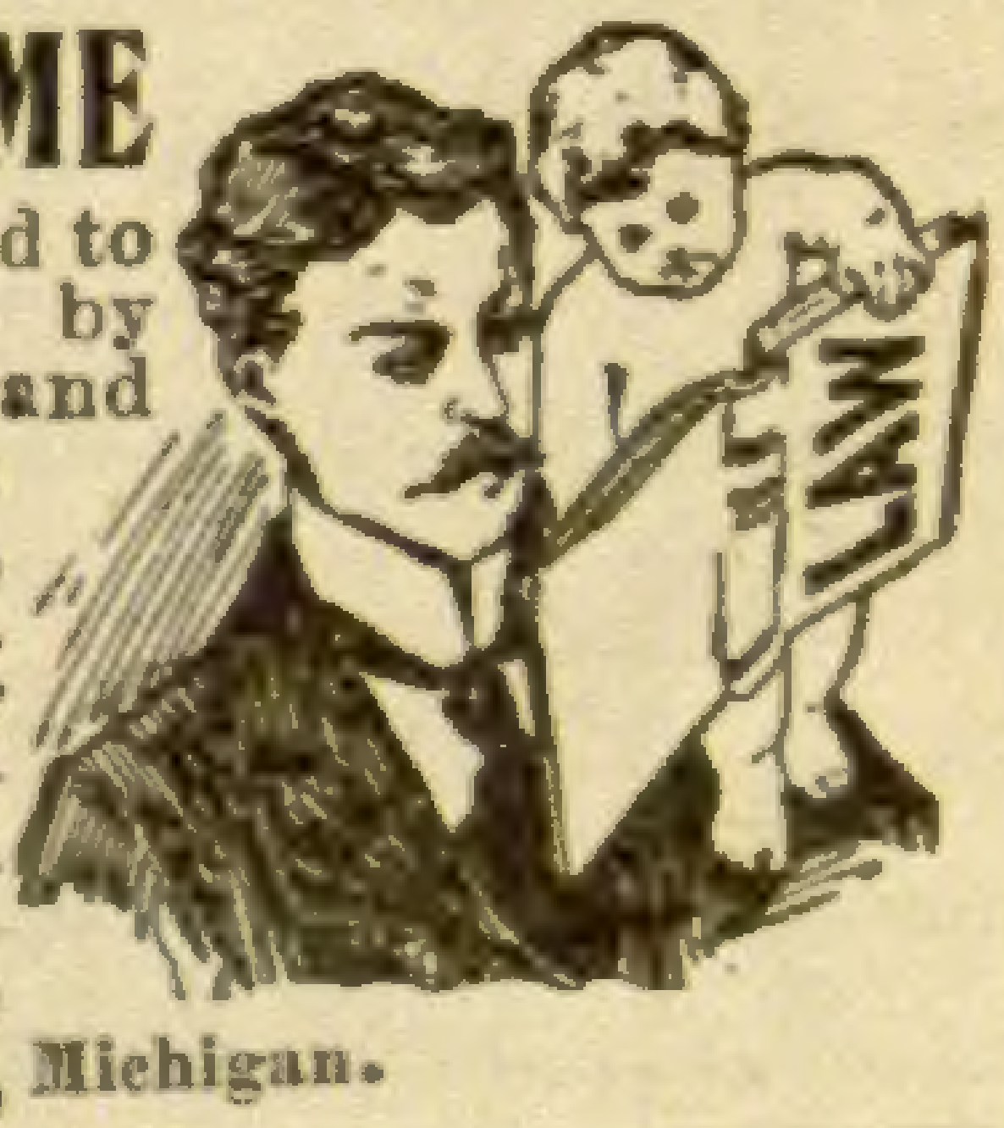

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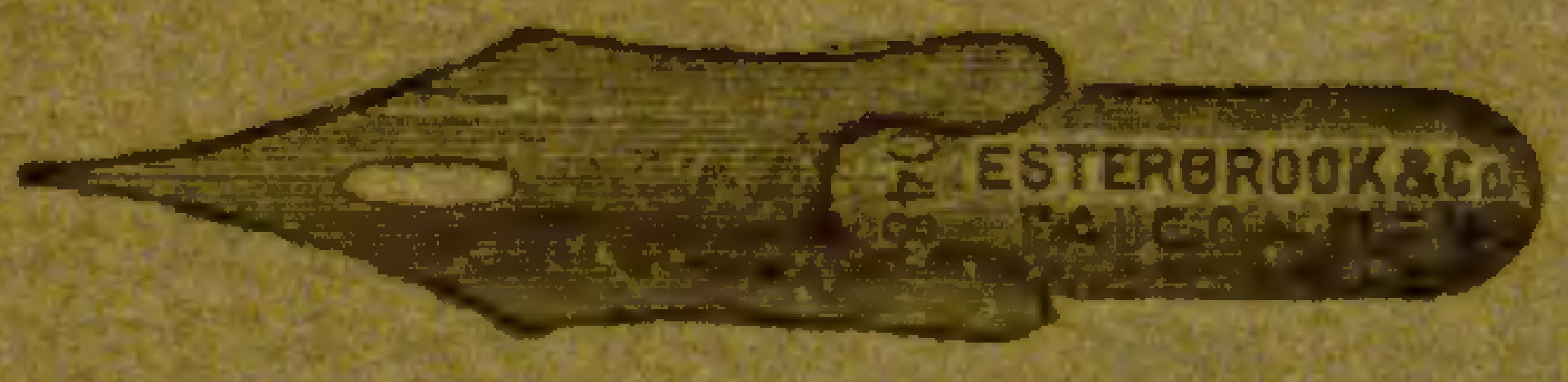

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